Radio, Electronics and Communications

FORMERLY "RADIO & ELECTRICAL REVIEW" — WIDELY KNOWN SINCE 1946 AS "R. & E."

MPL

In This Issue . . .

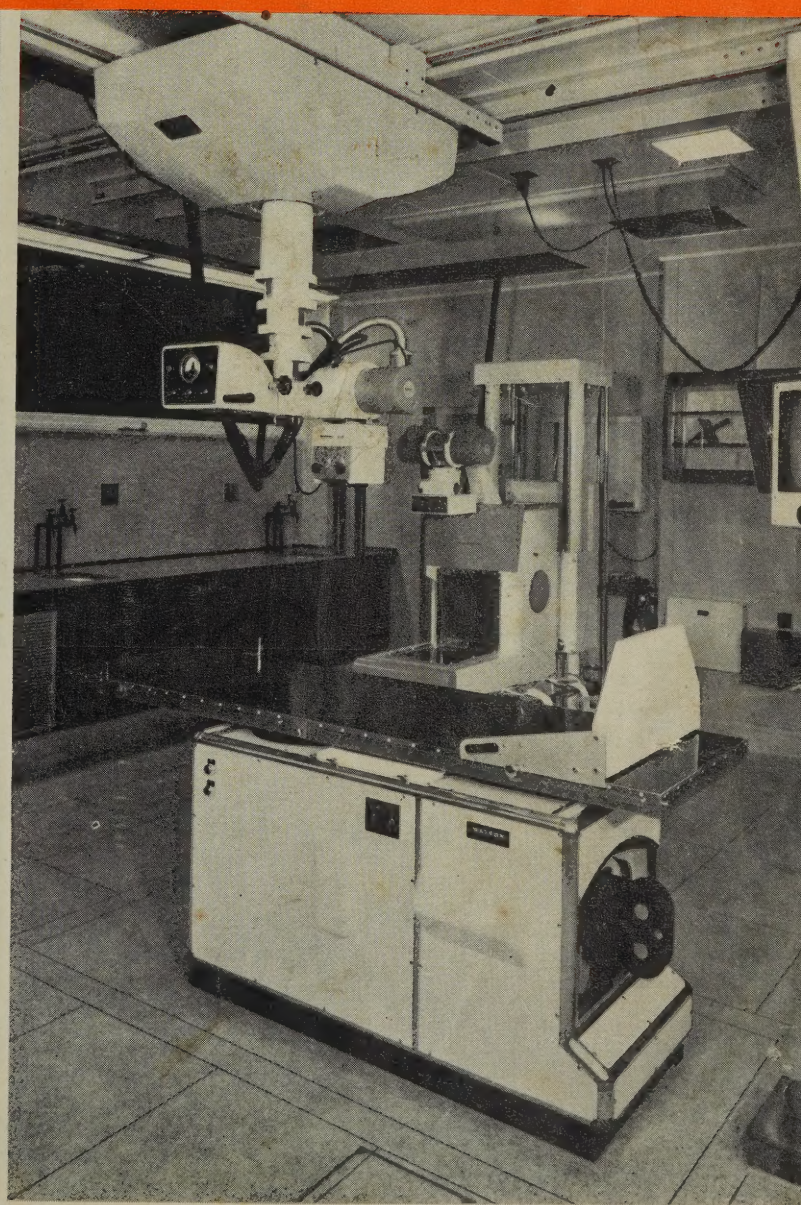
- A fast rise quadruple Pulse Generator.
- Mobile Communications — Part VII.
- Instrumentation in the field of Acoustics.
- Serviceman's Column.
- Listening Post.
- Editorial: Proposed Electronics Conference, 1966.

PUBLISHED MONTHLY IN THE INTERESTS OF THE N.Z. ELECTRONICS INDUSTRY FOR ALL LEVELS, FROM PROFESSIONAL TO AMATEUR.

VOLUME 20 NUMBER 10

DECEMBER 1, 1965

PRICE 2/6



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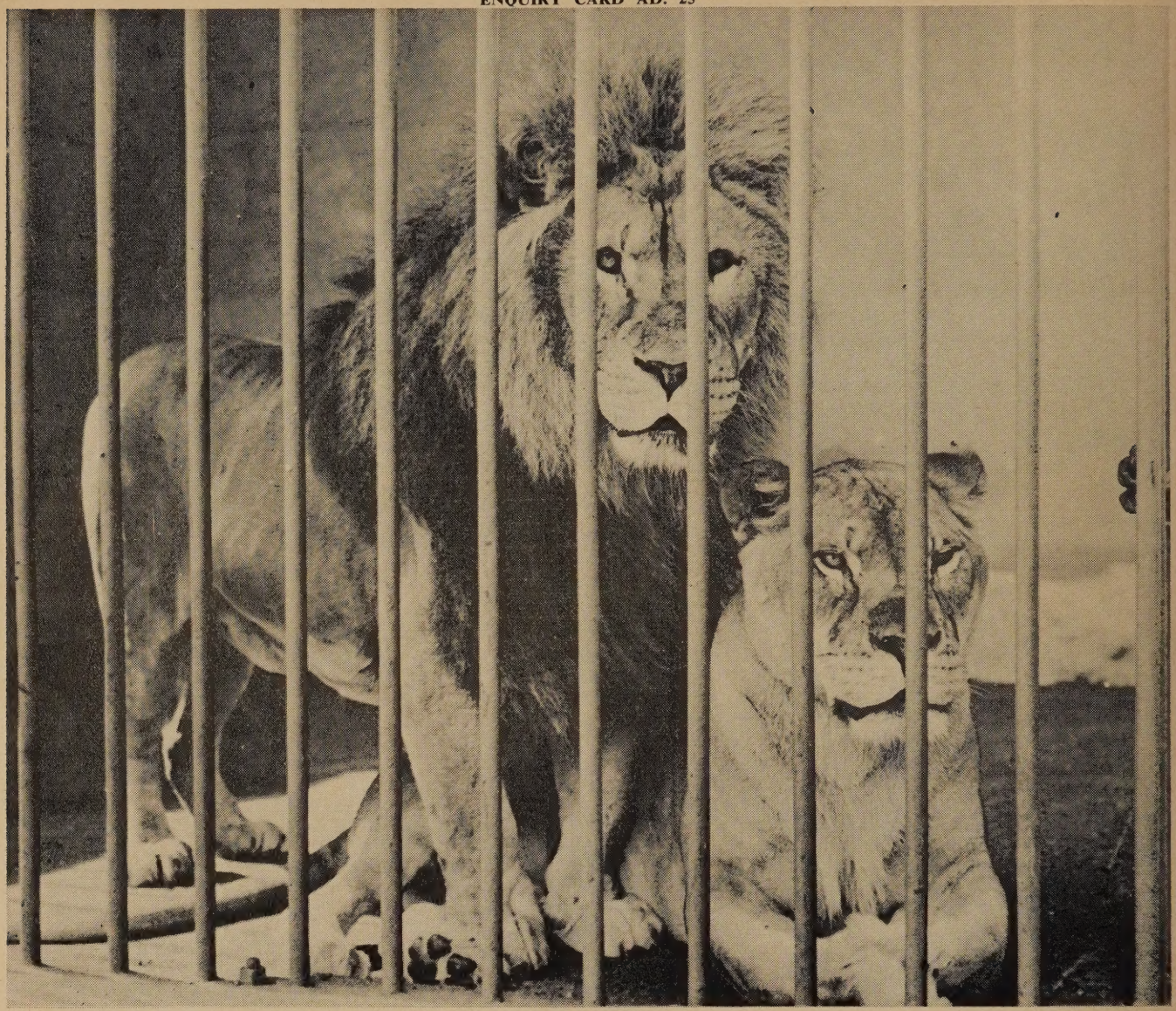

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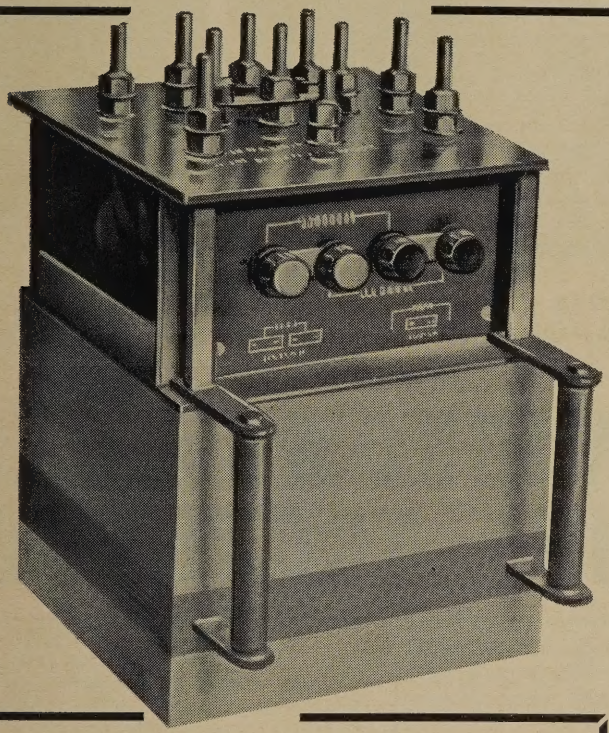
MODEL HTL/64



Nominal Rating	4.8 kVA
Primary Volts	230/400-460
Secondaries	4 x 15V 80 amp Continuous 1 x 3.3 x 80 amp Continuous (for Buck/Boost operation) 1 x 110V 1.5 amp for Timers etc.
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ENQUIRY CARD AD. 5

Are you neglecting bolometer mount efficiency in your measurements ?

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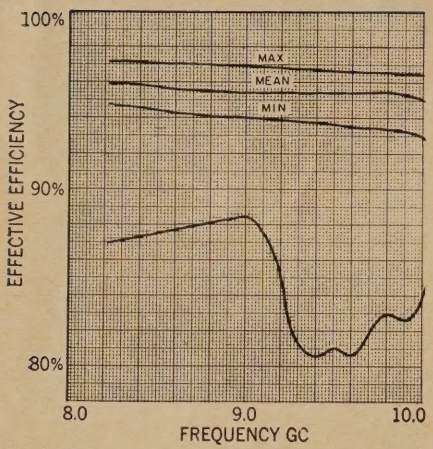
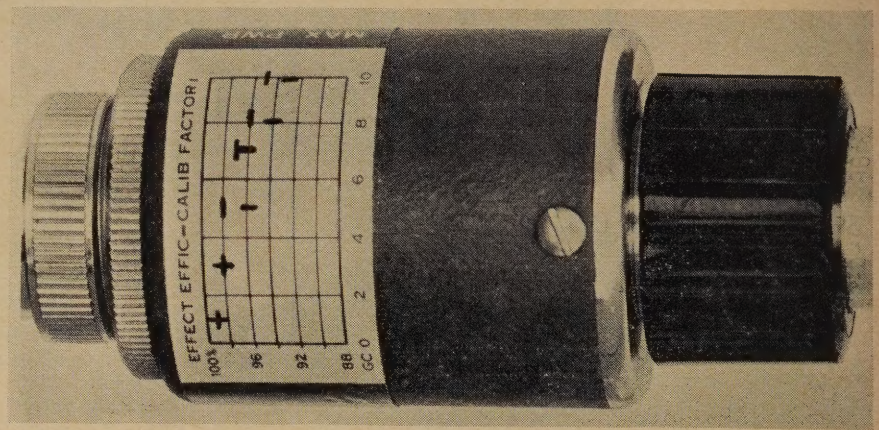


The upper traces show efficiency range of hp's 478A; lower trace shows non-hp manufactured mount.



Hewlett-Packard 478A Thermistor Mount with new custom-calibrated efficiency plots, traceable to NBS where possible, delivered with every mount!

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The calibration at points not yet on the NBS schedule is based on interim standards established at Hewlett-Packard after years of designing, manufacturing and testing thermistor mounts. Literally thousands of tests and measurements have gone into the development of these standards, including cross-check against NBS-calibrated mounts wherever possible. Thus efficiency data is provided at many points in addition to those on the NBS schedule to facilitate interpolation and help you make more accurate power measurements more easily. For convenient access, the data is stamped directly on the nameplate of each mount.

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Radio, Electronics and Communications

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Vol. 20, No. 10 December 1, 1965

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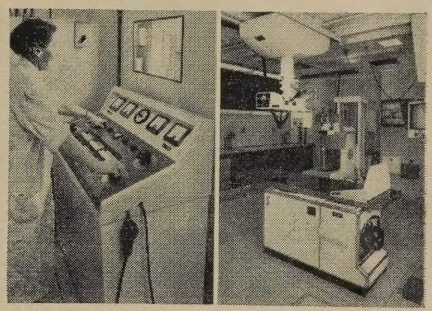
On Our Cover



The complexity of specialised equipments recently ordered by the North Canterbury Hospital Board from Amalgamated Wireless (Australasia) N.Z. Limited to provide facilities at the Princess Margaret Hospital for Cardiac Catheterisation emphasizes the specialisation in radiography today.

This will be the third Cardiac Catheterisation room installed by AWA, whose engineers have acquired highly specialised knowledge of the techniques involved, not only in television image intensifiers, but also in the application of rapid film changers employed in diagnostic radiology.

Our front cover shows a 1000 ma X-Ray control unit and a catheter table. The catheter table incorporates an undertable Cinelix image intensifier. The ceiling tube crane is positioned over the table and at the right of this picture, the television monitor screen can be seen suspended from the ceiling. The equipment illustrated forms the major part of the complete installation which will be installed by X-Ray engineers of the Christchurch branch of AWA.

The complete diagnostic system will comprise a 1000 ma X-Ray control and generator, Elema-Schonander Rapid film changers, Odelca television image intensifier, Watson ceiling tube crane and numerous related accessories.

ENQUIRY CARD AD. 6

COMING . . .

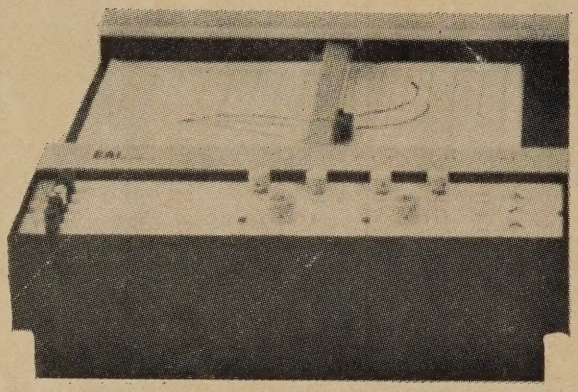
V.L.F. Propagation — Part II
Instrumentation in the field of acoustics — Part II
Communication Receiver Design
432 meg Transmitter
A look at Signal Generators
Special Avionic Review

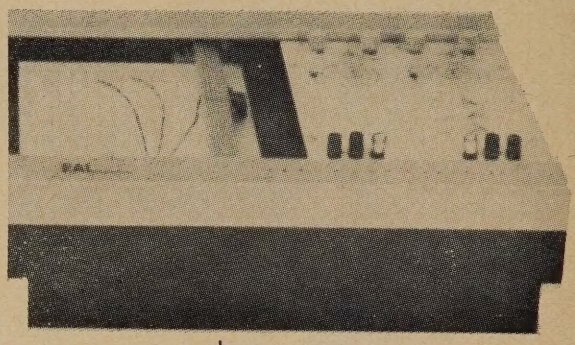
ALSO . . .

Serviceman's Column
Camera View
New Products
Book Reviews
Listening Post
Electronic Institute news

ENQUIRY CARD AD. 7

This stainless steel tape is one reason why our new low cost X-Y recorders stay accurate to 0.1%





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We call it the "direct-drive tape." It is part of the rugged, single-loop, linear, ball-bearing drive system which replaces the complex pulley and string drive you have been accustomed to in other X-Y recorders. Based on 15 years of experience in building premium quality recorders, these versatile instruments are new in concept, quality and reliability in the low-price field. Both the 8½" x 11" and 11" x 17" recorders offer such valuable features as precision slide-wire feedback potentiometers; a quiet vacuum system which will hold any size or shape of paper; zener diode reference; built-in time base; and all solid-state circuitry for as little as $U.S.1450.

Specifications:
Static accuracy—0.1%
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18 Calibrated D-C Ranges—
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Letters from Readers

Sir,

I am anxious to obtain — borrow or buy — plans for the bass horn of the Klipschorn. These may be published in some periodical. If so I would be glad to know where — and get hold of a copy. Or, one of the readers may have this information, and/or plans.

I wonder whether one of your readers may be able to help?

At the moment I am interested in the transistorised amplifier articles, and thinking in terms of 8-10 watts channel I am interested in the efficiency of the bass horn. Incidently the bridge circuit published in the August 'Gramophone' works well, with some power loss, and the centre derived channel is well worth it with wide spaced speakers.

Thanking you,
D. J. KEALL,
Matawhero,
Gisborne, R.D. 1.

We hope one of our readers may be able to assist you either directly or through this office. —Ed.

Sir,

In your September issue of Radio, Electronics & Communications there is a circuit for a stereo amplifier.

However on page 14 in the preamp circuit there is a condenser in which the value has been left out.

Would you please send me the value and working voltage. The condenser is about one inch below the first transistor.

R. K. DAHL,
Palmerston North.

The information you requested was published as a note in October issue. A cutting of this correction has been posted to you in case you do not have the issue on hand. —Ed.

Sir,

I have been given a copy of the circuit of a transistor stereo amplifier which, I believe, was featured in the September, 1965, issue. Unfortunately the value of the electrolytic capacitor in the emitter circuit of the first RCA 40233 in the pre-amp is unmarked in my diagram, as is the rating and type number of the power transformer.

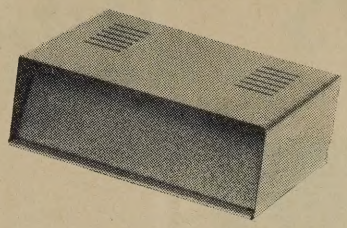
I would be grateful if you could give me details of these two components.

Could you also please give an idea of the output power ratings of the amplifier.

Z. A. PETHERICK,
Auckland.

It appears you do not have the complete article which discussed the transformer and output power ratings. Therefore a copy has been sent to you. We have also sent you the details of capacitor as they appear in a note in October issue. —Ed.

ENQUIRY CARD AD. 9



NEW CABINETS

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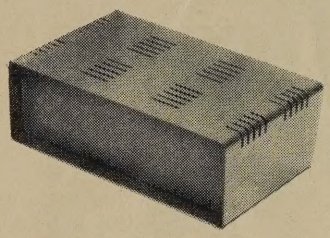
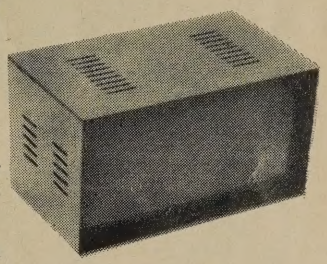


Suitable for any amplifier 12" long x 8" deep x 4½" high



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EF 1E	VTVM Application series—How to use VTVM	£6/19/0	IT 12E	Signal Tracer	£14/6/6
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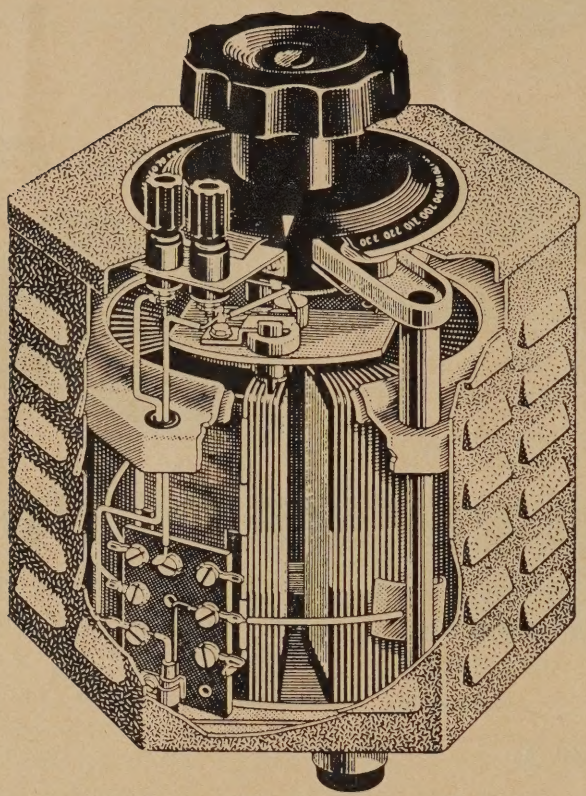
PHILIPS *Variable transformers*



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Electronics In Action

"Electronics in Action" is the theme for the first national electronics conference, sponsored jointly by the New Zealand Electronics Institute Inc. and the Institution of Electronic and Radio Engineers (N.Z. Section). The conference will be held next year in Auckland commencing on August 17, for four days with excursions and social activities up until August 20.

It will be the first opportunity for N.Z. engineers, scientists and technical personnel to attend a conference solely devoted to electronics and to gain benefit from technical lectures as well as from discussions with others in their fields. Co-ordination between various personnel in Government departments, universities, and commercial firms can benefit the electronics industry immensely. Only too often are two or more organisations working in parallel fields without knowledge of one another's common developments and problems.

Electronics does not enjoy sufficient recognition in New Zealand. To often it is casually classified along with other research and development projects. How many scientific organisations do not need electronics in some form or another to assist in their work? Both industry and the Government departments must realise this in their clamour for professional and technical staff and thus there is a need for collaboration between a composite body and the employers. Certainly the universities and technical colleges are offering all the assistance they can, but only through public recognition of electronics as a profession can more students be encouraged to enter what will surely be one of the most active and rewarding professions. This then is the secondary aim of the conference — to provide recognition and urge consolidated support amongst those concerned.

The conference will provide expert coverage of a wide range of topics catering for the majority of persons and these will be detailed later under the following major sections: data handling; modern communications (radio and television); research electronics; industrial electronics; medical electronics; electronics in aviation and meteorology; nucleonics; electronics education. Additional activities will include a large scale trade exhibition, excursions, technical film showings and social intertainment. It is envisaged that specialist papers will be provided typically covering applications of electronics in fields such as VLF propagation, frequency and time measurements, NMR studies, power engineering, industrial controls, geophysics, chemical engineering, soil testing, biological research, upper atmospheric and ionospheric research, acoustics, mechanical engineering and so on. The recent eleventh New Zealand Science Congress did provide opportunities for discussions on the basic theory of work done in these fields, but did not allow for discussion on the means by which electronics were employed. This is felt to be most important, for a worker active in a particular unrelated field should have knowledge of the equipment being used, and be able to realise, the ways in which techniques can be improved. Often one application of a system can be adapted for use in different circumstances. For this reason the conference will also be of value to those engaged in work other than pure electronics.

ELECTRONICS CONGRESS IS PLANNED

A three-day electronics conference for New Zealand engineers and technicians, sponsored by the New Zealand Electronics Institute and the Institution of Electronic and Radio Engineers (London) is proposed for August, 1966, in Auckland.

An organising session was held at Auckland University with Professor K. Kreielsheimer, of the physics department, as acting-chairman. Representatives of the Naval Research Laboratory, the Auckland Industrial Development Laboratories, local industry and the two sponsoring societies attended.

Reproduced from N.Z. Herald

Many comments have been made about the apathetic response of the "industry" toward what must be beneficial co-operation, and the organisers of 'electronics in action' believe action will be the solution. Not only is action required of the organisers but more importantly, the engineering, technical and scientific personnel who should attend. Those who wish to ensure that they will be kept informed of all arrangements should return the Enquiry Card on page 38 suitably marked Reference No. EC38 and show their name and address. Initial enquiries regarding presentation of papers should be made to The Secretary, National Electronics Conference, P.O. Box 3325, Auckland.

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on application note from Philips

on the EL503 in class AB push-pull operation

For studying the performance of the EL503 an experimental output stage was constructed in which the tubes are operating under idealised conditions. This output stage consists of a low-distortion drive transformer, two tubes EL503 in class AB push-pull adjustment, a standard output transformer and a variable load resistance connected across the primary. Stabilised supply voltages were available for the anodes and screen grids (Fig. 1).

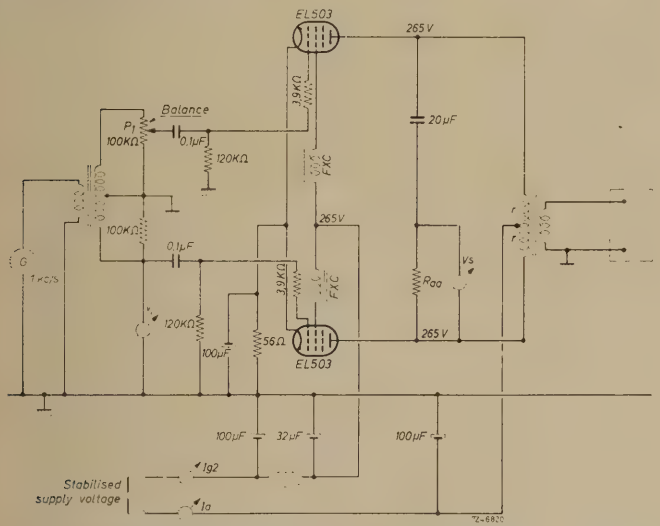


Fig. 1. Experimental output stage with 2 pentodes EL503 in class AB push-pull operation.

In order to reduce even harmonic distortion the symmetry of the drive voltages to the control grids can be adjusted with potentiometer P1. The supply voltages to the anodes and to the screen grids can also be individually adjusted to compensate for d.c. losses in the output transformer and in the smoothing choke. The output power was measured across the primary of the output transformer.

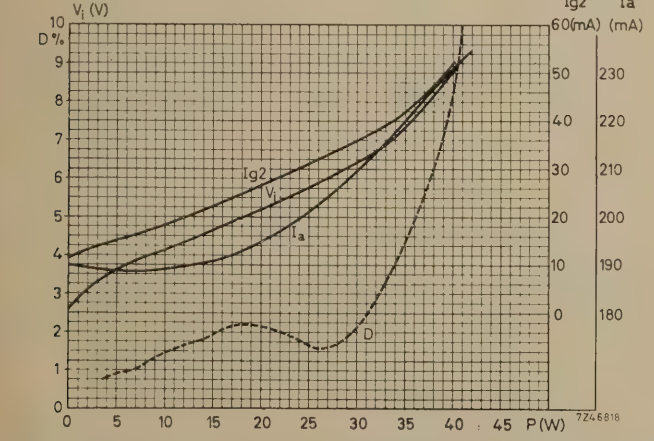


Fig. 2. Drive voltage (Vi), total anode current (Ia), total screen grid current (Ig_2) and distortion (Da) as function of the output power measured across Raa.

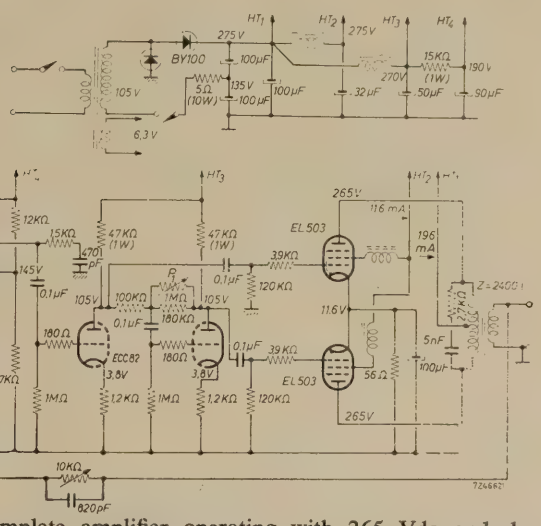


Fig. 4. Complete amplifier operating with 265 Vdc and delivering 30 watts with less than 0.5% distortion at an input voltage of 0.2Vrms.

It should be noted that when the amplifier is driven into class B operation (maximum output power) the resistance of the primary causes a considerable power loss; if r is the resistance of one half of the primary the power **supplied** by the output tubes can be expressed as follows:

$$Ps = P \text{ (measured in Raa)}. \frac{Raa + 2r}{Raa}$$

The curves of Fig. 2 show that for Raa = 2400 Ohms and r = 110 Ohms, 36.5 watts of output power are **available** at 5% distortion. In this case the output tubes have to **supply**:

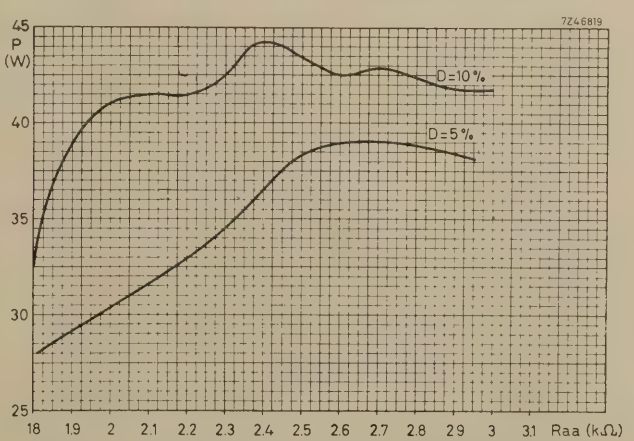
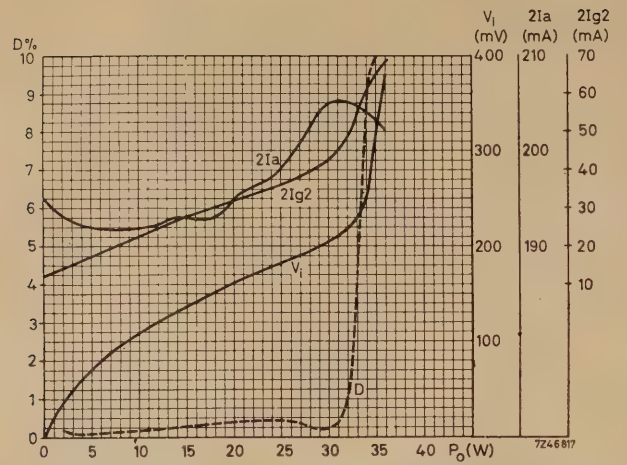


Fig. 3. Output power as function of the load resistance Raa for 5% and 10% distortion respectively.



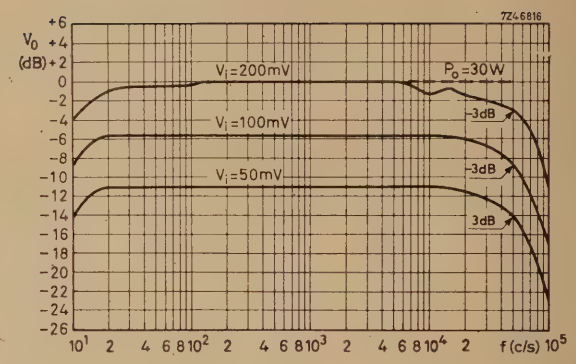


Fig. 5. Complete AF amplifier with two pentodes EL503
(a) Required input voltage, anode and screen grid currents and distortion as function of the output power.
(b) Frequency response for various input voltages.

$$Ps = 36.5 \left(\frac{2400 + 220}{2400}\right) = 40 \text{ watts}$$

At 10% distortion the available and the supplied output power are 44 watts and 48.5 watts respectively (Fig. 3).

The required drive voltage for 36.5 watts available output is 10.5 Vrms; for 44 watts 14 Vrms is required.

The power efficiency of the output stage is high; when the supplied output power (Ps = 40 watts) is related to the total anode-dissipation of the tubes, the power efficiency

Continued on page 35

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PROBES for use with Oscilloscopes

by M. F. Stanley *

Improvements in the design of oscilloscope vertical amplifiers and the requirement for higher orders of measuring accuracies, have resulted in the requirement for higher input impedances presented by the oscilloscope to the waveform source under investigation.

Various probes are manufactured which reduce the loading effect of the oscilloscope and this article describes the principle types used.

In recent years the many major advances into the various fields of technology have resulted in the requirement for oscilloscopes with more stringent specifications. These requirements have included higher orders of amplitude measuring accuracies, with vertical amplifier bandwidths extending to 100Mc/s and beyond.

However, such improvements that are made within the instrument itself are of no advantage if termination of the vertical amplifier input socket is made indiscriminately. Thus when observing the waveform on the oscilloscope screen, the question is always with us. Is what we see a true representation of the waveform, as it was before we connected the oscilloscope to the source?

The input terminals of most typical vertical deflection systems consist of a shunt resistance of 1MΩ in parallel with a small shunt capacitance of 12–47 pf. When we connect an oscilloscope to a waveform source, we should always consider whether this resistive capacitive loading caused by the vertical input circuit has altered in any way the waveform that existed before connection was made.

Figure one shows an equivalent waveform source connected to a vertical input circuit of an oscilloscope. The source is considered as a perfect generator in series with an internal impedance Zg.

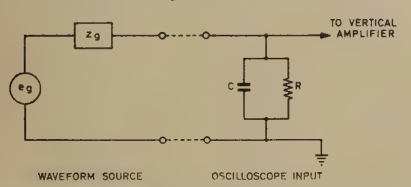


Figure one: The equivalent circuit of the vertical input to an Oscilloscope shown connected to a waveform source.

When the source voltage eg is applied to the vertical input circuit of the oscilloscope, a small signal current will flow into the resistive capacitive combination which represents the vertical input circuit. This small signal shunt current can cause a noticeable voltage drop across the source impedance Zg. Such a voltage drop can possibly change the amplitude or shape of the waveform at the vertical input socket. Thus the resulting display on the oscilloscope screen is not a faithful reproduction of the original waveform.

Providing that the waveform source has no rapid rates of change, then the loading effect of the vertical input shunt capacitance is small, and very little distortion in the shape of the applied waveform will result. However, if the source impedance Zg is large the amplitude of the applied waveform can be reduced due to the loading effect of the shunt resistance R of the oscilloscope input circuit.

If rapid rates of change are present in the applied waveform then relatively large signal currents will flow in the vertical input shunt capacitance. This large current flowing into the capacitance has a waveform which differs from that of the applied voltage waveform, and will cause a corresponding voltage drop across the source impedance. The resulting distortion can include both shape and amplitude and will be greater when the source impedance Zg is large.

Thus if the internal impedance Zg of the source is small, then the loading effect of the vertical input circuit has only a relatively small effect upon the amplitude or shape of the displayed waveform.

Oscilloscope Probes

Many oscilloscopes have listed among their accessories, various forms of probes and cables, to be used as connecting links between the device under investigation and the input to the vertical deflection system. The principle types of probes used are the simple or direct probe, the passive or active high impedance probe and the high voltage probe.

Direct Probe

The simplest connecting link for use with an oscilloscope is in the form of a coaxial cable with a probe tip. The cable or probe lead can add to the vertical input shunt capacitance of the oscilloscope as much as 20pf to 50pf depending upon the length and type of cable used.

This is exemplified when using the probe lead TM 8120 with the Marconi oscilloscope TF 1331A. The probe shunt capacity is approximately 30pf which, when added to that of the oscilloscope's vertical input capacity, will give an overall input shunt capacity of 60pf. This extra capacitance must be considered when trying to establish an accurate representation of the waveform under investigation.

High Impedance Probes

If whilst using the probe lead and oscilloscope as desribed above, full use is to be made of the oscilloscope's vertical amplifier bandwidth capabilities, the source impedance of the waveform generator under investigation must always be relatively low in value. Figure two shows the amount of attenuation that occurs with increasing source impedance, at a frequency of 1 Mc/s, using a direct probe with the TF 1331A.

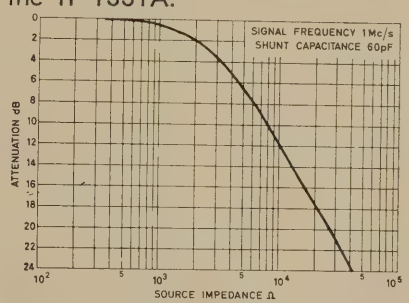


Figure two: Variation of attenuation with source impedance.

If the waveform source impedance is high, or higher frequency components are present in the signal, or perhaps a resonant circuit is to be investigated, then the low input impedance presented by the oscilloscope with or without the simple probe lead, can result in erroneous signals being displayed. To avoid this undesirable loading

* Marconi Instruments Limited.

effect the vertical input shunt capacitance must be sufficiently reduced, thus increasing the input impedance of the oscilloscope. This condition is achieved by the use of a high impedance probe.

There are two types of high impedance probes in general use. A passive device which uses a compensated voltage divider technique and the other an active device using the cathode follower.

Passive Probe

The simple circuit of the high impedance passive probe is shown in Figure three (a) with the equivalent circuit in Figure three (b).

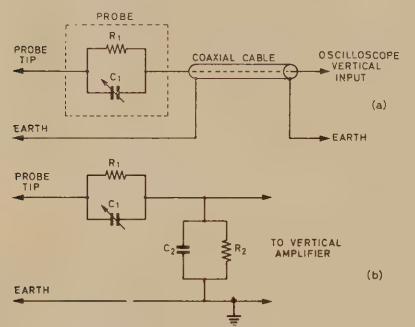


Figure three: (a) The basic circuit of a high passive probe. (b) The equivalent circuit of

Neglecting the compensating capacitors C1 and C2, the basic voltage divider probe consists of a length of coaxial cable in series with a large value resistor R1. When the probe is used between the waveform source and the oscilloscope's vertical input terminals, the amount of resistance which loads the waveform source is increased. Thus the amount of signal current flowing into the vertical input circuit is reduced resulting in less amplitude loss and waveform distortion at the source output terminals.

However a voltage division now occurs, the voltage divider being made up of the input resistor R1 and that of the shunt resistance of the oscilloscope R2. The amplitude of the signal at the vertical input terminals is reduced by the factor $\frac{R2}{R1 + R2}$.

The values of R1 and R2 are usually chosen to give a convenient attenuation ratio, the most common being 10 to 1. In general, oscilloscope vertical input circuits have a shunt resistance of 1MΩ, and R1 is adjusted to be 9MΩ, giving an overall input resistance of 10MΩ.

It is desirable to maintain this attenuation ratio practically constant for low and high frequencies, therefore the probe must have some form of frequency compensation for the entire frequency range over which it is to be used. If R1 and C1 is made equal to R2 and C2 then the two time constants are equalised and the probe will attenuate all frequencies of the applied voltage waveform in the same proportion. In practice the capacitor C1, located in the probe head, is made variable so that the frequency compensation of the divider can be carried out by the user. This facility is very necessary due to the variation of vertical input shunt capacitance that occurs from one oscilloscope to another, and indeed in some cases from one vertical input attenuator step to another.

It is therefore advisable before using a high impedance probe with an oscilloscope to ensure that it is correctly compensated. This can easily be carried out by applying to the probe suitable square wave signals, and adjusting the variable capacitor C1 until the flatest top is displayed as shown in Figure four.

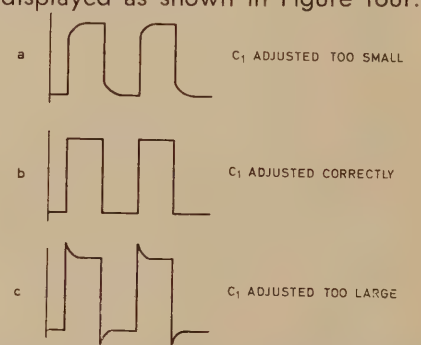


Figure four: (a) Shows the condition where the shunt capacitance C_2 in fig. 3 (b) has made the attenuation ratio of $\frac{R_2}{R_1 + R_2}$ greater at high frequencies then the attenuation ratio of medium and low frequencies. (b) The condition where the shunt capacitance C_1 of the probe resistor R_1, fig. 3 (b), has been adjusted correctly to give the same attenuation ratio at high frequencies to that at medium and low frequencies. (c) The probe capacitance C_1 has been made too large and the attenuation ratio at high frequencies is lower than that at medium and low frequencies.

Low capacity coaxial cable is used to minimise the amount of distributed capacity that is added to the vertical input shunt capacitance C2. Also with R2 very high, of the order of 1MΩ, the cable is presented with a serious mismatch when viewing signals from a low impedance source. This can cause distortion of pulse waveforms with fast rise-time, and it is usual therefore for the inner conductor of the cable to be made resistive, the value of which is chosen to give the best possible wave shape.

An example of the very latest in the design of high impedance probes for use with oscilloscopes is a new probe manufactured by Marconi.

This probe has primarily been designed for use with Marconi Instruments oscilloscopes whose vertical input circuits consists of 1MΩ shunted by approximately 30pf. It can also be adjusted to suit other oscilloscopes having vertical input shunt capacitances ranging between 10 and 60pf; the bandwidth of the probe is reduced with oscilloscopes having large values of shunt capacitance.

A unique feature is the addition of a switch to enable the user to switch from an attenuation ratio of x 10 with input resistance of 10MΩ to that of x 1 with input resistance of 1MΩ. The switch action is achieved by a simple action of rotating the probe nose through 60° with location assured by a positive click action. Thus the user has the choice of the two types of passive probes housed within the one probe body.

Other features include greater robustness due to a specially designed inner conductor in the coaxial cable, an input capacitance of only 9.5pf (x 10) or 70pf (x 1) when used with a vertical input circuit of 1MΩ shunted by 30 pf, and a rise time of approximately 7 n sec (x 10). The rise time of the X1 position will depend upon the source impedance of the applied signal.

Figure five shows the response of the probe when used with a Marconi TF 2200A oscilloscope. The source impedance presented to the probe was 500Ω an dthe pulse rise time 1 nanosec. The excessive distortion that can occur to pulses with fast rise times is demonstrated in figure five (bottom). Here the low input impedance of the X1 position of the probe is seen loading the 50Ω source impedance of the pulse generator.

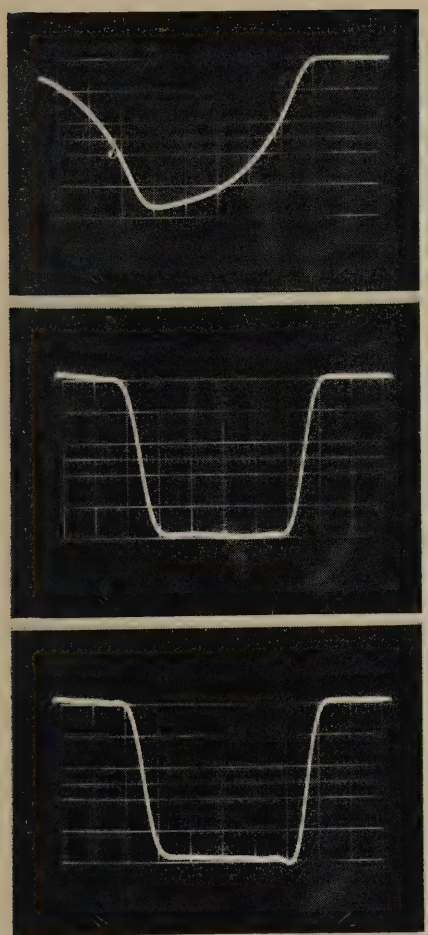


Figure five: Pulse response of the Marconi Instruments passive probe when used with the oscilloscope type TF 2200A.
(a) Shows the response of the Oscilloscope to a pulse of risetime < 1 nanosec with a source impedance of 50 Ω.
(c) Demonstrates the excessive Pulse distortion that can occur when the waveform source is loaded by a low impedance.

High Voltage Probes

When viewing voltage waveforms the amplitude of which is greater than the allowable voltage rating given in the manufacturers instructions, recourse must be made to a special high voltage probe. These operate in a similar fashion to that of the lower-voltage divider probes, but with a higher attenuation factor.

Typical d.c. ratings are 12 kilovolts with an input shunt resistance of the order of 100MΩ and a shunt capacitance of 3pf.

For voltages in excess of 12 kilovolts a capacitive voltage-divider probe is recommended. This type of probe can handle signals with amplitudes of the order of 50 kilovolts. A typical capacitive high-voltage divider probe is shown in Figure six.

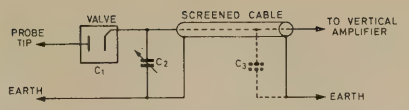


Figure six: A Capacitive voltage divider probe circuit where the first capacitor C_1 is a high voltage rectifier valve. Use is made of the valves anode to cathode inter-electrode capacitance, which can be of the order of 1 to 2 pf. Breakdown voltage is often in excess of 15 KV. The value of C_3 is obtained from the addition of the distributed cable capacitance and that of the Oscilloscope vertical input shunt capacitance.

Active Probe

When viewing waveforms of low amplitude, the attenuation factor of the passive high impedance probe is not wanted due to the requirements for higher gain conditions in the vertical amplifier system. To overcome this problem requires the use of a specially designed amplifier with the probe. The amplifier consists of a miniature valve connected as a cathode follower with the probe tip connected to the control grid and the ground lead connected to the grounded end of the cathode circuit. The output is taken from the cathode and fed into the vertical input socket of the oscilloscope.

The high input impedance of this probe is achieved due to the characteristics of the cathode follower, which are that its input resistance is very high usually greater than 100MΩ, and its input grid capacitance is low, namely: —

$$Cin = Cga + Cgk\ (1\text{-}A)$$

Where A is the gain of the cathode follower,
Cga is the grid to anode capacitance of the valve,
Cgk is the grid to cathode capacitance of the valve.

A typical active probe circuit is shown in Figure seven.

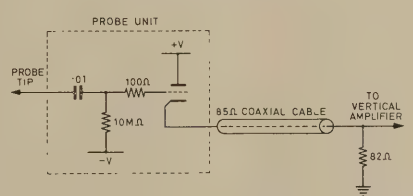


Figure seven: The basic circuit of a typical cathode follower probe.

This circuit will present to the waveform source being investigated a load consisting of 8pf in parallel with 10MΩ. The 85 coaxial cable connecting the probe housing to the vertical input socket is matched at the probe end by the output resistance of the valve and at the oscilloscope end with an 82Ω resistor.

This method of connection causes the loss of nearly half the voltage amplitude of signal but ensures good pulse response and a flat frequency response which is less than 0.5 db in error at 30 Mc/s. However, this type of cathode follower circuit is essentially of the small signal wideband type and the input signal is not recommended to exceed 3V p-p for faithful reproduction.

Cathode follower probes can, however, be obtained with attenuator heads when the input signals exceed a few volts in order to minimize amplitude distortion.

The operating voltages for the cathode follower valve are generally obtained directly from the oscilloscope's power supply via a special socket usually located on the front panel of the instrument.

Detector Probe

A further type of probe used in the response analysis of tuned circuits is that of the detector probe. Aligning a tuned circuit is usually done visually by sweeping the bandwidth of the circuit with a high frequency f.m. voltage. As only the shape of the response is desired and not the high frequency carrier, the output signal from the tuned circuit is detected by the probe before being applied to the oscilloscope vertical input.

There are many types of detector probes but basically the probe consists of a diode detector circuit which can be of either the series type or the shunt type, the former being the most sensitive is shown in Figure eight.

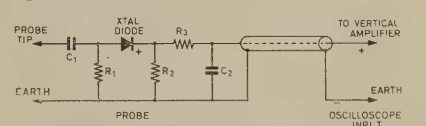


Figure eight: A demodulator probe, series type.

Conclusion

It has been shown that for a faithful reproduction of a waveform voltage due consideration must be made to the loading effect of the vertical input circuit of the oscilloscope. Various probes are manufactured to minimise this loading effect, the characteristics of each type being designed for use in solving their particular measuring problems.

Fast Rise Quadruple Pulse Generator

By W. R. STEPHENSON, B.Sc. *

INTRODUCTION

A need existed at Physics & Engineering Laboratory, D.S.I.R. for a fast rise multiple pulse generator in order to test high speed logic circuits, and measure resolution time of counters. At the time the project was started no such instrument was available commercially.

In fast rise generators, avalanche circuits have the advantage of simplicity, and disadvantages of limitation of amplitude by transistor dissipation, limitation of repetition rate by long recovery time, and instability in certain configurations. After consideration of these facts, avalanche circuits were adopted throughout.

SUMMARY

The generator has four channels. It delivers a positive or negative pulse of one volt amplitude into 70 ohms, on each channel. Output pulses from each channel may be delayed from 200 ns to 5 μs with respect to a synchronising pulse, in one range. The synchronising pulses may be triggered externally, or internally with rates from 1 kc/s to 30 kc/s in five ranges. The length of output pulses from each channel may be varied from 20 ns to 2.5 μs in 11 ranges. In the present version, charge storage effects in the output transistors limit the current switching performance. "Current on" has a 0.8 ns switching time accompanied by a 200% overshoot, and "current off" has a 10 ns switching time. These may be improved. (See Appendix Two).

GENERAL DESCRIPTION

Fig. 1 is a functional and timing diagram which indicates the way in which the basic units are combined to achieve the desired pulse forms. As the avalanche mode is not well known, a preliminary discussion of the fundamentals will be given.

If Vcc is sufficiently high, the collector potential of the transistor in Fig. 2(a) has two stable states. If the emitter-base junction is biassed off the collector assumes a potential $-(V_B - Vbb)$, where V_B is the collector-base breakdown voltage for which Ico is multiplied by collision to the constant current $[Vcc - (V_B - Vbb)]/Rc$. If the emitter-base junction is biassed on, the collector assumes a voltage $V\alpha$ with respect to the base. $V\alpha$ is the voltage at which avalanche multiplication replaces carriers lost in diffusion across the base.

Now $V\alpha$ is required to produce a multiplication $\frac{1}{\delta}$ (δ is the fraction of carriers leaving the emitter that arrive at the collector) while V_B produces a multiplication of Ic/Ico. As Ico is the order of a few μa normally

$$\frac{Ic}{Ico} > \frac{1}{\delta}$$

Hence as multiplication increases with collector-base voltage, in general

$$|V_B| > |V\alpha|$$

Consider now the variant of Fig. 2(b). In the normal state, the emitter-base junction is held off, and is triggered on by a negative pulse to the base. The emitter current then rises, and the capacitor begins to discharge rapidly. This can occur at nanosecond speed as the carriers are subject to a large accelerating potential, and carrier densities are high because of ionisation.

Thus in a few nanoseconds the collector potential rises to less than $V\alpha$ (because of excess carriers in the base). If the trigger is kept on, the collector will recover to $V\alpha$, but if it is removed after the initiation of the avalanche, Cc charges via Rc and Vcc until the collector again reaches V_B, when the transistor is ready for the next trigger pulse.

If Vb is supplied by the network in Fig. 3, the circuit can function in two distinct ways.

(a) If $\frac{Vcc - (V_B - Vb)}{Rc} < \frac{(Vbb - Vb)}{Rb}$ then the collector current is smaller than the current in Rb, there is always current in the diode, and the emitter-base junction is always biassed off by the forward drop of the diode. Each time the circuit is triggered, it goes through the cycle described above, and remains inactive until the next trigger.

(b) If, however, $\frac{Vcc - (V_B - Vb)}{Rc} > \frac{(Vbb - Vb)}{Rb}$ when no charging current flows out of the condenser, Ic must flow through Rb, the diode is biassed off, and the emitter junction is biassed on.

When Cc is charging, Ic flows from Cc rather than through the base-collector junction, a current flows from Vbb through Rb, turning the diode on, and holding the emitter-base junction off. However, when the capacitor reaches $(V_B - Vb)$, the stable point, the constant current Ic flows in Rb, biassing the emitter junction on, making the capacitor discharge. Again Ic is switched from Rb to Cc and the cycle is repeated continuously.

That is, when $\frac{Vcc - (V_B - Vb)}{Rc} > \frac{(Vbb - Vb)}{Rb}$ the circuit functions as a relaxation oscillator.

THE TRIGGER CIRCUIT See Fig. 4

This regenerative trigger is provided so that positive and negative trigger inputs, and internal

* Scientist, Physics and Engineering Laboratory, D.S.I.R., Gracefield, Wellington.

trigger pulses of the repetitive mode may be converted to a standard input to the delay section.

The circuit is a modification of Fig. 2. Repetitive or triggered operation is provided by switching either 2 ma or 1/5 ma through the OA 5 as described in the previous section. The diode-resistor combination in the emitter lead allows positive trigger on the emitter as well as negative trigger on the base. The 47 ohm resistor limits the current during regeneration in order to prolong the life of the transistor. In the repetitive mode, the charging time of Cc, hence the period, is altered by coarse variation of Cc and fine variation of Ic by altering Rc. Rc is driven from a — 135 volt point in order that a wire wound potentiometer can be used without exceeding the dissipation of the transistor. In the same way, the maximum collector current is limited to 2 ma by the 56 K collector resistor.

Provision is made in the "standby" position to stop this initial stage so that the steady state of the outputs may be examined. The output needle pulse is coupled to the delays by means of the 15pf capacitors.

THE DELAY CIRCUIT See Fig. 5

This is a diode current switching circuit, used to initiate a ramp on the base of a regenerative trigger. The diode is switched for a period greater than the maximum delay by a pulse from a blocking oscillator driven by a square loop ferrite core.

In the steady state the avalanche transistor is biassed off, Ib flows as shown, and the base is at +V. When its anode is pulsed negative by means of the blocking oscillator output coil C, the diode is cut off. Then Ib begins to charge Cb, dragging the base negative. When the trigger point is reached, a time (CVRb)/Vcc later, an output pulse occurs. For the rest of the square pulse, Ib flows through the emitter-base junction in the forward direction.

Further regenerative pulses can occur by an unknown process unless Cc is chosen so that the relaxation period is greater than the square pulse length.

A blocking oscillator as in Fig. 6 using a square loop ferrite toroid was chosen to supply the low impedance square pulse. The delay circuit is given in Fig 5. The normal state is with D_2 cut off as $V_B > 12V$ for ASZ23. When the circuit is triggered, the collector rises to less than $V\alpha$ ($< 12V$ for ASZ23). Hence a current of 100 ma flows in the 50 turn winding, overcoming the constant m.m.f. of 2 500 ma. turn in the reset winding and driving the core toward the opposite direction of magnetisation. The initiation of switching is fast, as a large current flows in the coil as Cc is discharged.

In the usual avalanche trigger the collector potential would begin to fall towards V_B, but here the switching flux linked with the 14 turn coil biasses the emitter-base junction on. The latter limits the rate of change of flux by the low impedance of the saturated emitter. When the flux has switched, the base bias is removed and the avalanche transistor collector returns to V_B. This means D_2 is cut off, only 1 ma flows in the collector coil, and the reset m.m.f. drives the coil to the opposite direction of magnetisation. The pulse period is determined by the base emitter diode damping the flux change. As voltage equals rate of change of flux

$$\frac{n_b \phi}{t} = Vcb$$

$$\text{so} \quad t = \frac{n_b \phi}{Vcb}$$

Where ϕ is the switched flux, twice the remanent flux of the material

Vcb is the turn-on potential of the emitter-base diode,

n_b is the number of turns on the base winding

and empirically, $S = (Fc - K)\ T$

Where Fc is the applied m.m.f.,

K an m.m.f. associated with the coercive force of the ferrite,

S is the switching constant for the core, and

T is the switching time.

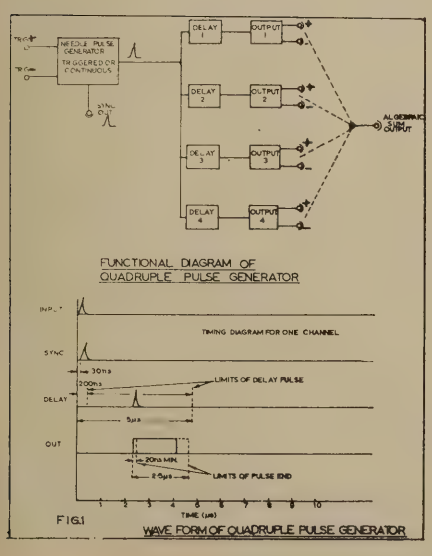


FIG.1

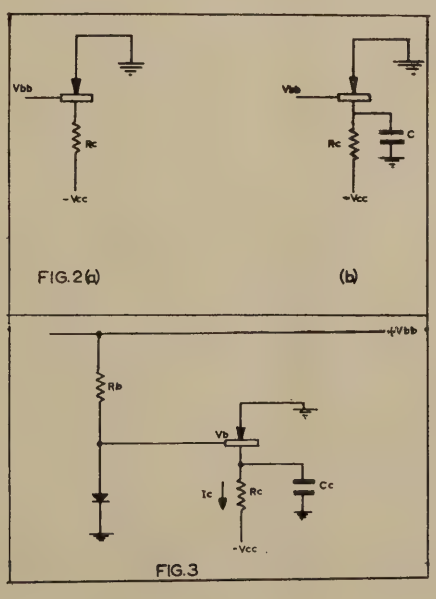


FIG.2(a) (b)

FIG.3

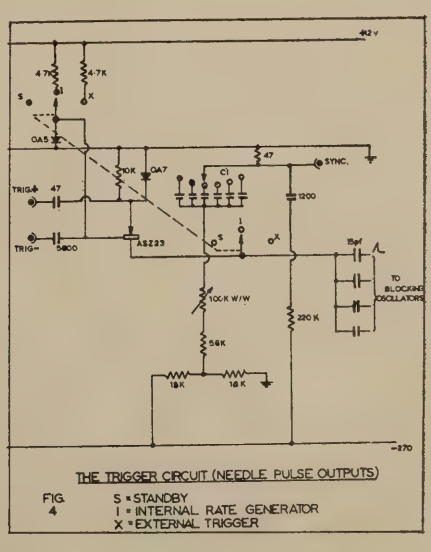
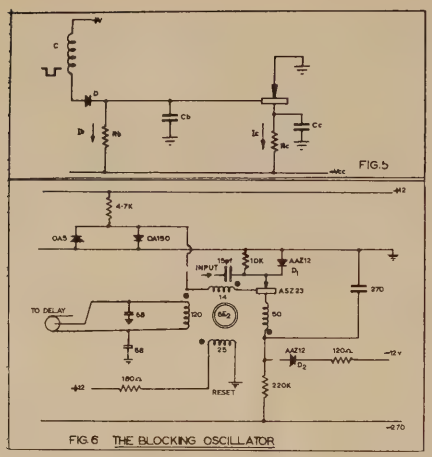
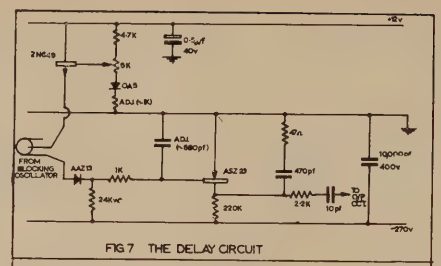
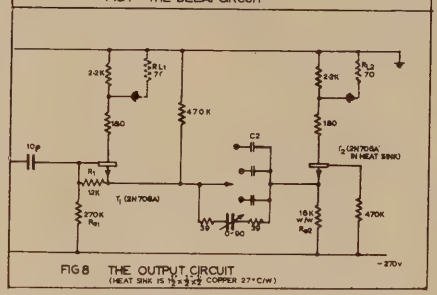
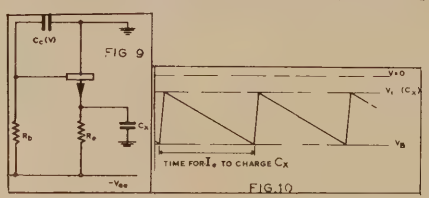


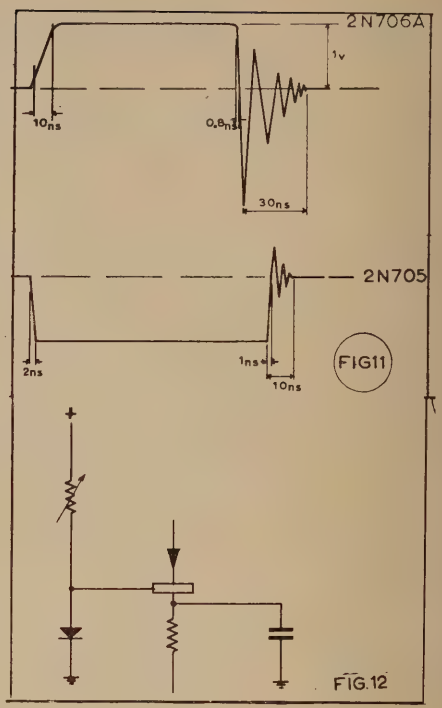
FIG. 4 S = STANDBY
I = INTERNAL RATE GENERATOR
X = EXTERNAL TRIGGER











Above: **Fig. 6. Blocking Oscillator.**
Centre: **Fig. 7. Delay Circuit.**
Fig. 8. Output Circuit.
Fig. 9 and Fig. 10.
Right: **Fig. 11 and Fig. 12.**

The two 68 pf condensers bypass transient effects due to the avalanche which may make the ramp non linear.

The practical embodiment of the delay is shown in Fig. 7. The emitter of the 2N649 is held at nearly its base potential, irrespective of current, thus defining the voltage V from which rundown starts. Temperature effects of the OA5, 2N649, AAZ13 and ASZ23 are nearly compensating. Less than 1ns/°C variation of delay was noted.

A 1KΩ resistor is included in the base lead of the ASZ23 to minimise loading on the output coil of the blocking oscillator. Without it, the blocking oscillator will not function.

Part of Cb comprises the inherent 500pf emitter-base junction capacity of the ASZ23.

The output pulse from the delay section is supplied via the high impedance of 2.2 KΩ and 10pf in series, for a purpose explained later.

THE OUTPUT CIRCUIT

The output circuit is shown in Fig. 8. It is a monostable, current switching circuit in which T_2 is normally conducting. In the stable state the voltage between the emitter and collector of T_2 is is $V\alpha_2$ and the current flowing $(Vcc - V\alpha_2)/Re_2$. The transistor T_1 normally passes only a small current defined by the high value of Re_1 and equal to $(Vcc - V_{B1})/Re_1$. It is this same current flowing in R_1 which reverse biasses the emitter-base junction of T_1 and causes the collector-emitter voltage to equal V_{B1}. The circuit is triggered into its other state by the application of a positive pulse to the base of T_1 of sufficient amplitude to overcome the reverse bias. T_1 becomes more highly conducting and the voltage across it begins to decrease from V_{B1} to $V\alpha_1$. Most of this change of voltage appears at the emitter of T_2 reverse biassing the base-emitter junction and reducing the voltage across the transsistor to $V\alpha_2 - (V_{B1} - V\alpha_1)$ thereby stopping its conduction and reducing the voltage across R_{L2} to zero. All the current flowing in Re_2 now flows through C_2 to the emitter of T_1 and thence through R_{L1}. C_2 is accumulating charge and the voltage across it is increasing. This increase is taking the emitter of T_2 more negative and this continues until the voltage across T_2 is $\sim V_{B2}$. At this point T_2 becomes highly conducting and the voltage across it drops to $V\alpha_2$ as it once more draws all the current flowing in Re_2. The current is diverted from T_1 and the change of voltage at the emitter of T_2 equal to $V_{B2} - V\alpha_2$ is communicated to the emitter of T_1 thereby reducing the voltage across that transsistor to $V\alpha_1 - (V_{B2} - V\alpha_2)$ and returning it to the non-conducting state. The emitter of T_2 is returned to its original voltage of V_{B1} volts below ground by the current flowing in Re_1, and the circuit is ready to be triggered again. The pulse length is very nearly $[C_2 (V\alpha_2 + V\alpha_1 - V_{B2} - V_{B1}) Re_2]/Vcc$ nanoseconds for units of volts, picofarads and kilohms. The relevant waveforms are given in Fig. 19.

The 39 ohm resistors are to prevent ringing in the C_2 wiring.

When the 70 ohm terminated output plugs are removed, the — 270 volt supply is limited to — 30 V by the 2.2 K resistors in order to eliminate shock hazard.

In practice, the parameters V_B and $V\alpha$ vary between different transistors, and to achieve identical calibration on all channels, we can select matching transistors or alter the current defining resistor. In the latter case the output pulse amplitudes vary, but this was done on account of a local availability problem.

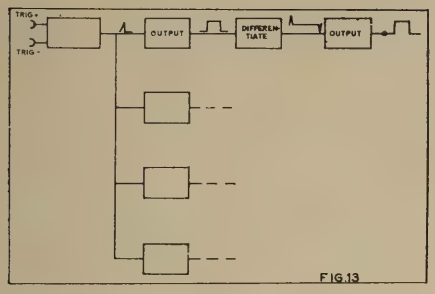
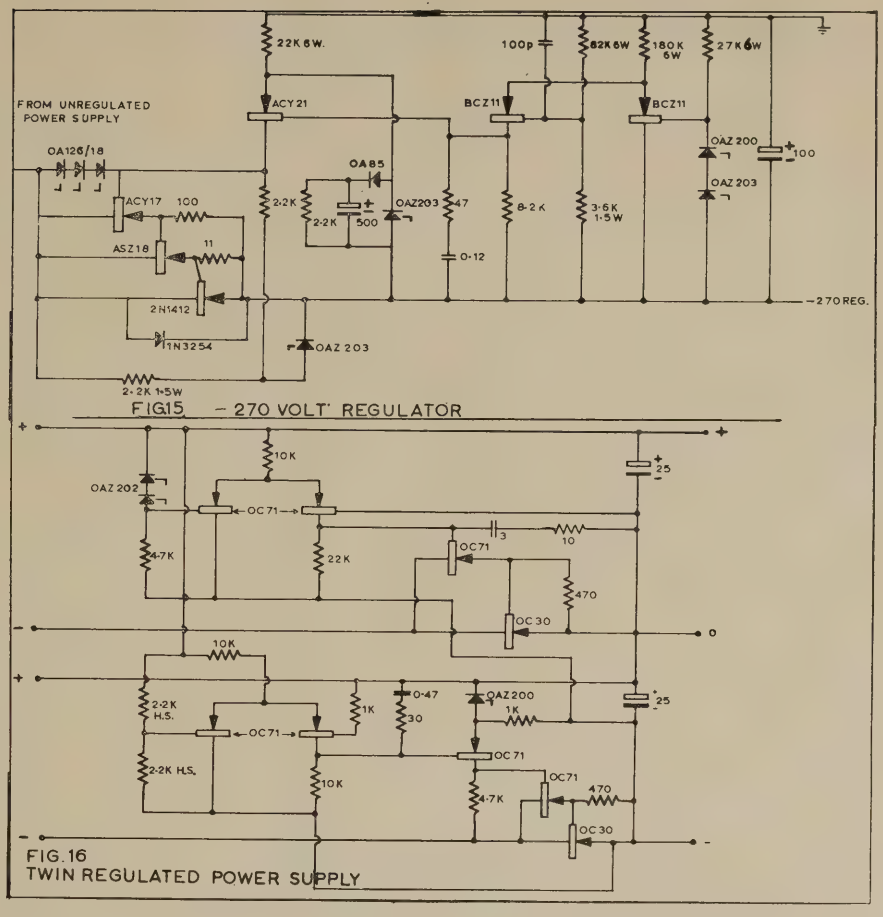


FIG.13



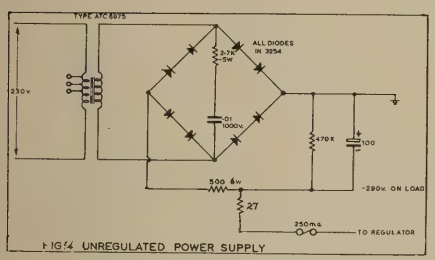


FIG.14 UNREGULATED POWER SUPPLY

Above: Fig. 13.

Below: Fig. 14. Unregulated Power Supply.

Upper Right: Fig. 15. 270 Volt Regulator.

Lower Right: Fig. 16. Twin Regulated Power Supply.

COMBINING PULSES

As four 20 m.a. currents are to be switched, diode mixing of the outputs was rejected, as high current diodes do not operate at the fast rise times observed. Instead, these constant currents are merely switched into a common load. To meet the problem of channels triggering one another, incoming transients are reduced by the 180 ohm resistor in each output which gives a transient attenuation of 2.5 times without unduly degrading the rise time. Also the emitter-base back bias on T_1 was made as large as possible consistent with the amplitude of the input signal which is limited by impedance consideration.

POWER SUPPLIES

Delay intervals, pulse periods and repetition periods are determined by constant currents derived from a high voltage negative supply. Thus to achieve low delay and pulse length jitter a well regulated supply must be used. Similarly the trigger points of stages must be maintained very constant, and for this a regulated +12 V supply is needed. The — 12 V supply alone need not be well regulated. For convenience, well tried supplies developed at P.E.L. were used. The circuit diagrams appear as Figs. 14-16 and Fig. 17 is a servicing diagram. Care must be taken in any modification to the —270 V supply as values have been chosen to give short circuit protection.

CONSTRUCTION

All units are built on double sided circuit board. The circuit is printed on one side only and the other side is left intact as an earth plane, but for holes drilled for clearance for pigtails of components. It is an established fact that high frequency circuits operate better near an earth plane, because of radiation considerations. A pulse of 1 ns rise time has a 1 000 mc/s bandwidth.

As all the blocking oscillators operate in phase and are initiated by the trigger circuit, these units are mounted on the same board. Each delay and output pair is mounted on a separate board to stop interchannel interference, and connections between blocking oscillators and delays are made with coaxial cable to stop radiation of triggering pulses. To a nanosecond pulse, six inches of wire becomes a half wave antenna.

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3. A Study of High Speed Avalanche Transistors. J. R. A. Beale, W. L. Stephenson and E. Wolfendale. PROC I.E.E. **104 B** p 394 July 1957.

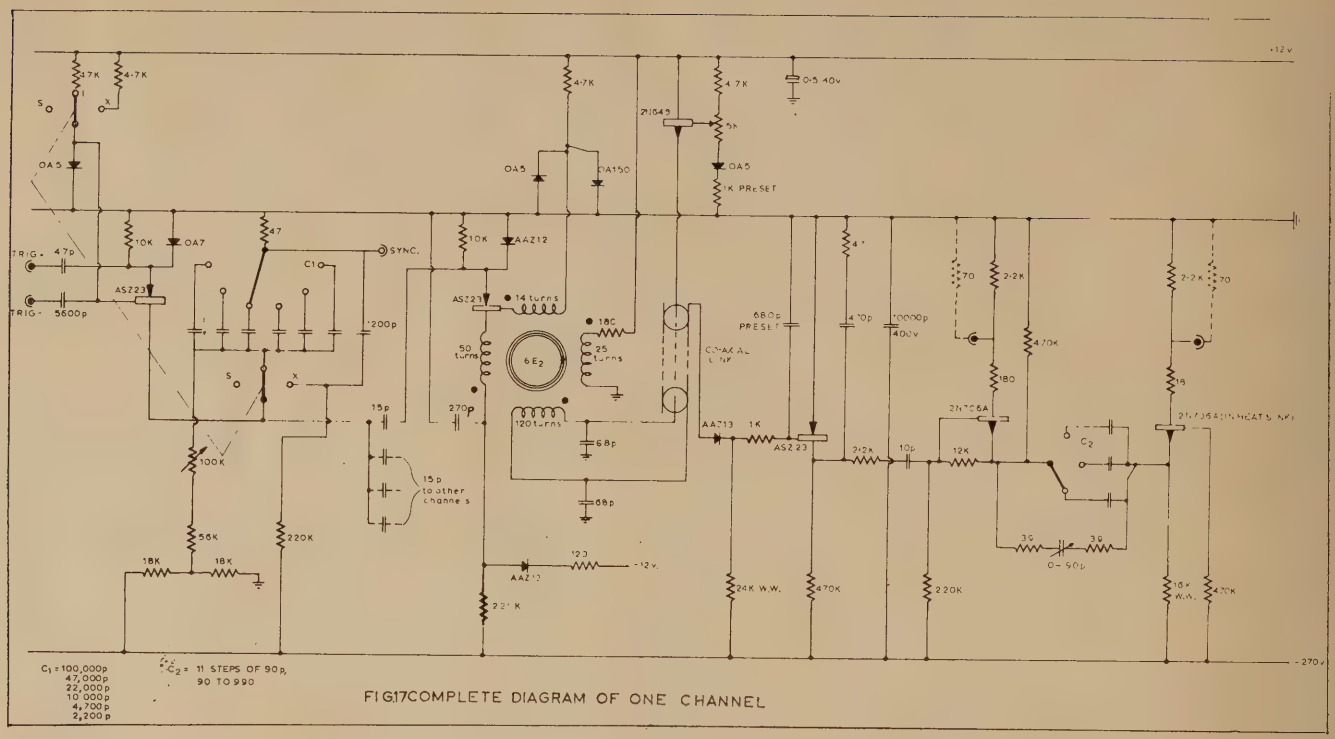


FIG.17 COMPLETE DIAGRAM OF ONE CHANNEL

APPENDIX ONE
INSTABILITIES IN THE OUTPUT CIRCUIT

The initial trial output circuit built was found to have discontinuities in the pulse length as the "coupling" capacitance was varied smoothly. Further investigation showed that a very high frequency ($\sim$ 50 mc/s) oscillation occurred in whichever transistor was conducting. This gave the rundown to $-V_B$ a sawtooth character which explained the step variation. Approach of an oscilloscope probe altered the character of the oscillation, which was deduced to be a consequence of stray capacitances. To make the phenomenon more easily observed, larger stray capacitances to ground were added, and emitter to ground stray was found to be the important factor. The waveform was observed to be as in Fig. 10 when 1 000pf emitter to ground capacitance was added. As circuit parameters were altered, certain broad dependencies were noted. The voltage V_1 in Fig. 10 was seen to be a function of the emitter to ground capacity, and whether or not the circuit oscillated depended on the ratio of standing emitter current to standing base current. An empirical improvement incorporated in the unit was use of a high impedance in the trigger circuit to reduce effective emitter to earth capactity.

For the purpose of the following analysis, we can use one equivalent circuit for each transistor of the output circuit; for T_1 during the pulse, and for T_2 at all other times. It is as in Fig. 9.

The mechanism of the observed oscillation is:— when the power supply is switched on, the base rapidly reaches V_B, as Cc is small. Then, with the emitter-base junction reverse biassed, the emitter potential falls towards V_B with Cx charging until sufficient emitter current can be injected into the collector junction and multiplied by avalanche effect.

Emitter potential now rises rapidly, and the base potential stays sufficiently below it for the emitter to remain forward biassed. The latter is a consequence of the large number of free holes generated during multiplication. When multiplication falls to such a low value that their rate of flow is unable to keep the emitter forward biassed, the cycle begins again. Let this occur at emitter (and base near enough) potential V_1. The emitter waveform then is as in Fig. 10.

For the configuration to be stable, the emitter should be forward biassed as the emitter reaches $V\alpha$. That is, Cx should charge from $V_1(Cx)$ to $V\alpha$ with Ie faster than $Cc(Vcb)$ charges from $V_1(Cx)$ to $V\alpha$ with charging current Ib. Expressed algebraically,

$$Cs = \frac{[Cc(V\alpha)\ V\alpha - Cc(V_1)\ V_1]\ Ie}{(V\alpha - V_1)\qquad Ib} \quad \text{in the region} \quad |V_1| < |V\alpha|$$

Where Cs is the critical value of Cx, below which the circuit is stable for given Cc, Ib and Ie.

V_1 may also be expressed algebraically as a charge dQ flowing from Cx becomes MdQ after multiplication at the collector barrier. $[(M - 1)dQ]/2$ of this is formed of holes, some or all of which may raise the potential of the base to keep the emitter conducting. Then the emitter turns off when this charge dQ makes a greater potential difference in Cx than $[dQ(M - 1]/2$ can make in Cc

$$\frac{dQ}{Cx} = \frac{dQ\ (M - 1)}{2\ Cc}$$

$$2\ Cc(V) = Cx\ [M(V) - 1] \text{ for } V = V_1$$

Now the assumptions that multiplication

$$M = \left[1 - \left(\frac{V}{V_B}\right)^n\right] \text{ occurs at the}$$

junction (where n is ~ 4 for Ge) and that the collector junction is abrupt with

$C = C_{CB}\ (V_B/V)^{\frac{1}{2}}$ may be introduced, yielding

$$\frac{2C_{CB}}{Cx} = \frac{X^{n+\frac{1}{2}}}{1 - X^n} \qquad \text{Where } X = \frac{V_1}{V_B}$$

for $2|V_1| < V_B$ we may reasonably put

$$\frac{2C_{CB}}{Cx} = X^{n+\frac{1}{2}}$$

for the 2N705 with $Cx = 1\ 000$pf

$C_{CB} = 3.5$pf ($Cc = 5$pf at 10V)
$V_B = 25$

$n = 4$,

$V_1 = 8{\cdot}5$ which is in fair agreement with the value of 5v observed.

Thus it has been established that as Cx increases, V_1 decreases, having a value of 8·5v at 1 000pf.

The theoretical variation of Cs (as a factor of deviation F from $Cs = [Cc(V\propto)Ie]/Ib$) with V_1 was tabulated for a few representative values.

For $V_1 = 8$, $V\propto = 10$, $V_B = 20$

$$F = \frac{C_{CB}\ (20/10)^{\frac{1}{2}}\ 2}{C_{CB}\ (20/10)^{\frac{1}{2}}\ 10 - C_{CB}\ (20/8)^{\frac{1}{2}}\ 8} = 1{\cdot}7$$

Tabulating the result of this calculation for values of V_1,

V_1 (volts)	F
8	1.7
5	1.71
2	1.45
1	1.3
6	1.8
7	1.82
0	1
$V\propto$	1

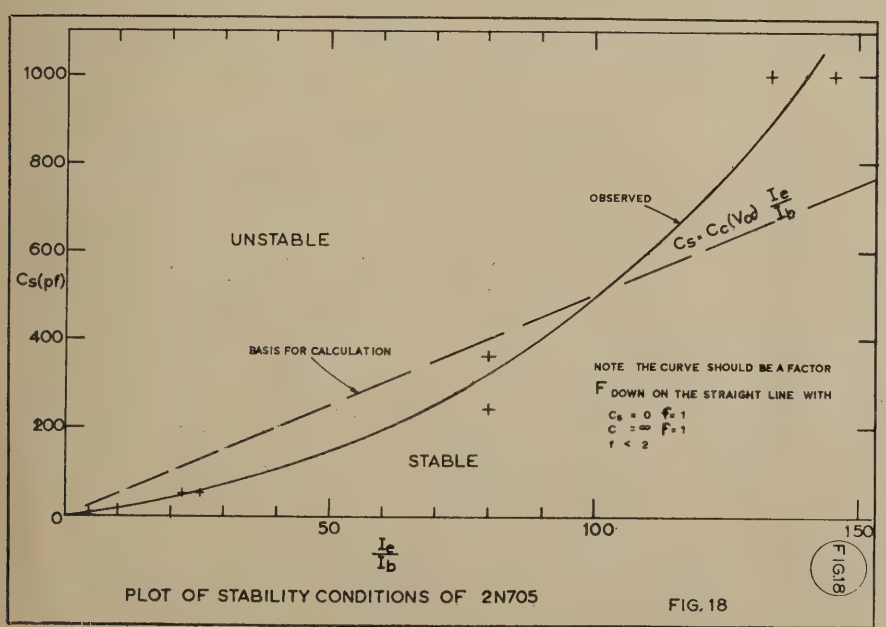
Bearing these in mind, together with the V_1 versus Cx law, a curve of the type observed and plotted in Fig. 18 is expected.

The above has established a theoretical basis for the observed characteristics of the instability, and suggests that it may be cured by selecting an appropriate ratio I_E/I_B or by padding the collector base capacity. Neither of these should affect the rise time (see reference 1) but the ratio I_E/I_B alters the mark/space ratio of the output circuit.

APPENDIX TWO

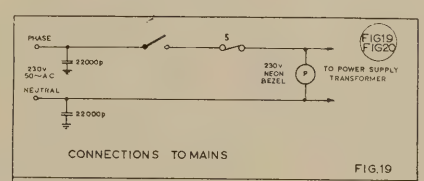
STORED CHARGE

In the output circuit, the difference in charge stored in the base region between breakdown and unity gain conditions is an important factor. Stored charged is released at "switch on", as a nanosecond transient, and the same amount must be accumulated at "switch off", resulting in a long rise time. Type 2N705 has much smaller stored charge than 2N706A, and the improvement in output waveform is readily seen (Fig. 11). The inversion of waveform is because the 2N706A is npn, the 2N705 pnp. Both waveforms are observed at corresponding parts of the circuit.



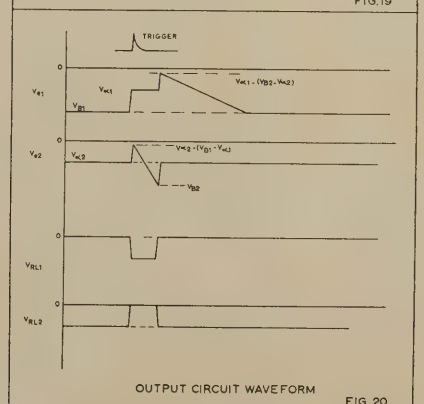
PLOT OF STABILITY CONDITIONS OF 2N705

FIG. 18



CONNECTIONS TO MAINS

FIG.19



OUTPUT CIRCUIT WAVEFORM

FIG. 20

APPENDIX THREE

TRIGGER LEVEL CONTROL

The base circuit of the input transistor may be altered to give amplitude control over both positive and negative trigger. The back bias of the base-emitter diode may be altered by using the fact that the forward drop of a diode is not constant, but dependent on current. A circuit is indicated in Fig. 12. The variable resistance must have a sufficiently low maximum value to ensure triggered operation.

APPENDIX FOUR

IMPROVEMENTS TO TIME DELAY CIRCUIT

(i) If a trigger transistor with emitter-base capacitance much less than the 500pf of the ASZ23 were used, delay could be obtained in several ranges by using different rundown rates, shunting the delay capacitor progressively.

(ii) A blocking oscillator with a much faster reset would allow a higher operating rate of the delay. This could be done using a square loop core of greater flux.

(iii) By using the "turn-off" of the output circuit to trigger another output, one could obtain a repetition rate varying with the delay used. Such a system would obviate the need for winding blocking oscillator toroids with many turns. The system would be as in Fig. 13.

CONCLUSION

Avalanche circuits have been developed to use locally available components, giving acceptable performance. A model has been derived to explain unsatisfactory aspects of performance. Use of this allows these occurrences to be avoided.

Although it has had limited use in the eight months since completion, the generator has proved easy to set up and reliable in operation. Because it is completely solid state, there is no warm up period, and because the action is basically current switching the outputs may be short circuited or subjected to d.c. voltages of less than 30v without harm.

Stable, fast operation has been achieved with simple circuitry.

LISTENING POST

by michael lawrence

All times are in GMT and frequencies in kilocycles

UNITED NATIONS RADIO

This station broadcasts news from the United Nations, when it is in session, daily from Tuesday to Saturday.

The programme for Australia and N.Z., formerly broadcast at 0730 and repeated at 0845, is now on the air only at 0845 and closes at 0900. Frequencies for this broadcast are 9665, 5985 and 11845. The first two frequencies are those of U.S. transmitters and the latter is a Honolulu relay.

Other English language transmissions from U.N. Radio between Tuesday and Saturday are: To The Far East from 0230-0245 on 17705, 15,185 (both Philippines transmitters), 17850 and 15365 (U.S. transmitters); To Central and South Africa from 0545-0600 on 9590 and 6125 (U.S.); To Southern Europe, Middle East and North Africa from 0630-0635 on 11790, 9615 and 7270 (Tangier); To West Africa from 0652-0700 on 9590 and 6125 (U.S.); To East Africa from 0700-0710 on 15315 and 11705 (Monrovia); To South East Asia from 1010-1020 on 17820 and 15395 (Philippines) and again from 1045-1100 on 15410 (Philippines); To Western and Central Europe from 1805-1810 on 15250 (Greenville) and 9710 (Tangier); To West and Central Africa from 1922-1930 on 17765 and 15350 (U.S.).

OTHER STATION NEWS

ALBANIA. Radio Tirana can be heard broadcasting each day in French from 0600-0630 and in English from 0630-0700 on a measured frequency of 7263. This frequency is announced by the station as being 7265.

Other broadcasts in English as announced by the station are: 0000-0030 on 7265; 2000-2030 on 7265 and 9390; and 2200-2230 on 7265 and 9390.

INDIA. All India Radio broadcasts news in English between 0800 and 0810 on 17890, and from 1140-1200 a broadcast in Thai to Thailand can be heard on 17705 and 21580.

PORTUGAL. The "Voice of the West" in Lisbon whose frequencies were given last month as being 7225 and 9645 for their transmission to Australia and N.Z. from 0730-0815 has now been observed on 17890 at this time. The two lower frequencies appear to have been vacated but the station continues to announce 7130 and 9645 as being the only frequencies for this transmission.

At 0800 All India Radio transmits on 17890 causing severe interference to Portugal.

The Africa Service provides good reception from 1800-1915 with a programme in English. The frequency in use for this transmission is 17880.

GERMAN DEMOCRATIC REPUBLIC. Radio Berlin International broadcasts a daily transmission in English to West Africa from 0615-0700 on 9575.

Other English transmissions to Africa are at 0345, 1215, 1315, 1600 and 1915.

U.S.A. Two 50 kW transmitters are used by WINB Red Lion for the transmission to North Africa. The frequencies are 17720 from 1700-2000 and 11795 from 2000-2200.

CUBA. Radio Habana Cuba has been heard around 0400 on 6135 with a transmission to North America; however reception was very poor.

FRANCE. From 0600-0645 Radiodiffusion-Television Francaise beams a programme in French to French Polynesia on 6175 and 9560 while, from 1300-1330, an English language broadcast is transmitted to the Far East on 21580, 15245 and 11850. From 1330-1400 these same frequencies carry a French programme.

NORTH VIETNAM. From Hanoi a programme is beamed to the American Servicemen in South Vietnam between 1300 and 1330 on 11760 and 9760.

Continued on page 35

SERVICEMAN'S COLUMN

Conducted by J. Whitley Stokes

During the course of a brief visit to the 'mainland', I took advantage of the opportunity to compare conditions in the trade and to make the acquaintance of some servicemen in the city of Christchurch.

It was with something of a shock that I realised it was quarter of a century, almost to the day, since I had last been in the Cathedral City, but in spite of this lapse of time it did not appear to have changed a great deal. For example, by comparision with Auckland, it was interesting to note that there are still about the same number of the smaller serviceman owned shops close in to the centre of the city, as was the case before the war. My impression was that life in Christchurch still moves at just a little more leisurely (to me something quite enviable) pace than it does in the so called 'Panic City'.

In speaking to servicemen I had only to mention I was from Auckland for it to be a signal for the commencement of a discussion comparing conditions existing in the two cities. However to be quite honest I must admit — apart from talking shop I made use of these opportunities to further a private interest in antique collecting. Here too I found a willingness to assist, one serviceman even going to the extent of shutting the door of his shop while he took me upstairs to see if he could find anything of interest.

As a result of this out of season sabbatical however, this month's column has suffered in the process but very conveniently as it happened, I found the following communication from T.C.K. (Wellington) awaiting on my return. In it our contributor deals with the servicing of those fortunately now obsolete mains-battery portables. I say fortunately as by and large they represented nothing but headaches to servicemen. This was not entirely due to poor design but was caused largely by an inherent weakness of the breed which resulted in their being susceptible to variations in power line voltage. This was certainly the case in the Auckland area and I don't doubt that the picture was much the same elsewhere. Of course it could be that M.E.D's. are more punctillious than E.P.B's. in the matter of voltage regulation. I wouldn't know about this but it seems strange to me that T.C.K. didn't mention this aspect when it was responsible for perhaps half the complaints of unsatisfactory operation received from owners of these sets.

You will notice the above remarks are in the past tense as indeed they should be for m/b portables are seldom encountered as repair jobs nowadays. Anyway let's see what T.C.K. has to say on the subject.

He writes:—

There was a vogue some ten years ago for the battery-electric portable. In its most sophisticated form the mains power unit could be used to depolarize the batteries between outdoor forays. There are a large number of these sets sitting around the countryside and we are often asked either to repair them or trade-in.

Most of the New Zealand manufactured models, there was Columbus, Pacemaker, Pacific and Ultimate to name the most popular, used large high tension batteries which were and still are inordinately expensive. If the set is to be recommissioned best forego the purchase of £3 worth of batteries which might have been manufactured some time ago. The radio, without the weight of the batteries, can be lifted by one person and can be carried from room to room. Most of these models were made before the advent of ferrite rod aerials and have loop aerials wound at the back of the cabinet. For this reason good reception without an exterior aerial can be had anywhere except in a ferro-concrete building.

There were fewer regional and "X" class stations operating then. Those that were usually ran restricted hours. In order to pull in the national stations these portables had a radio frequency amplifier valve ahead of the convertor and a pentode voltage amplifier following the detector diode. For some strange reason reflex circuits were not used by N.Z. manufacturers although they were across the Tasman.

For A.C. operation the valve heaters are run in series, using a dropping resistor and filter condenser fed from a metal rectifier (or later 6 x 4) and 110 volt transformer winding. The high tension supply was picked off before the filament dropping resistor and smoothed by conventional means.

These sets nearly all have power supply troubles. New 1000 mfd 25 volt condensers are smaller physically than the 400 mfd 12 volt type previously used. One portable even used two 50 mfd 25 volt in parallel but was hard on valves because of the ripple which does not show on a D.C. voltmeter but results in filament failure if the dropping resistors are lowered. Why, you ask, lower the dropping resistor? The valve chain requires 50 ma at 9 volts. The high tension requirements are about 15 ma at 90 volts. The forward resistance of selenium rectifiers increases with age. After ten years the forward resistance can build up sufficiently to get them good and hot. These are half wave rectifiers and the consumption during the negative half cycles has to be obtained during the positive half cycle. Either the rectifier can be replaced, and this in the worst cases is necessary, or (provided output is not below about two thirds required heater voltage) the dropping resistor shunted. One 5000 ohm 2 watt carbon resistor will bring voltage up on a nominal 9 volt chain from 6 to about 7 volts. The exact amount varies.

Continued on page 33

Measurements in Acoustics and Audio Engineering

by C. W. SALMON *

This paper is an enlarged and expanded version of a lecture given in November 1965 to a combined meeting of the N.Z. Electronics Institute and the Institution of Electronic & Radio Engineers at Auckland.

The recent publication of British Standard 3860: 1965 "methods of measuring and expressing the performance of Audio-frequency Amplifiers for domestic, public address and similar applications" means that an authoritative document is now available dealing with the methods of measuring amplifier performance. Up to now, in New Zealand, manufacturers and importers of equipment have been free to give performance figures related to any base they wish. More often than not, distortion, for instance, was given as a single figure (at one output level and at one frequency) with no regard for the fact that the distortion could be worse at other points — and usually was. Certain other definitions, such as the American term "Music power," give use to confusion in the mind of both the (British) manufacturer and buyer. The new Standard goes a long way to removing such confusion and the purpose of this paper is to discuss some of the instrumentation needed to undertake tests such as outlined in B.S. 3860 but the content extends to audio and acoustic measurements generally so that the subject may be of interest to a greater number of readers.

The growth of instrumentation in this field was greatly accelerated by wartime research during the 1940's and prior to that most instruments developed were the result of post office and telephone company requirements related to the transmission of speech over wire and radio circuits. The scope of instrumentation has, however, not greatly increased, rather reliability, cost and size have improved so that it is now much more feasible and less costly to carry out desirable tests. In field measurements, also, transistorization has brought reduction in weight and longer battery life and these are particularly important in building acoustic measurements.

Perhaps at this point mention should be made of the inclusion of both acoustics and audio engineering in the title. Strictly speaking acoustics include all branches of the physics of sound but over the years and particularly in America a division has been made that in practice means that acoustics deals with buildings and architectural work and audio engineering with sound reproduction especially in the entertainment field. Fortunately, the term "acoustics" is now being allied with "engineering", and the whole subject more properly called "acoustic engineering." Even this is a slight misnomer, because much building acoustics involves some subtle knowledge that the best engineer may never acquire — a little bit of art is needed, too.

The range of acoustic engineering nowadays extends from audio engineering (i.e. equipment design) to noise abatement and architectural acoustics but all these rely heavily upon electronic instruments so that the electronic engineer is becoming more involved in the bordering disciplines of machine design and building structures.

Historically, the subject is of some interest and names such as Lord Rayleigh, Sabine, Lissajon Newton and Doppler occur frequently, whilst much of the history is involved with study of the nature of sound and the physics of wave motion. Determination of the speed of sound is an example of quite early use of electrical impulses in timing circuits.

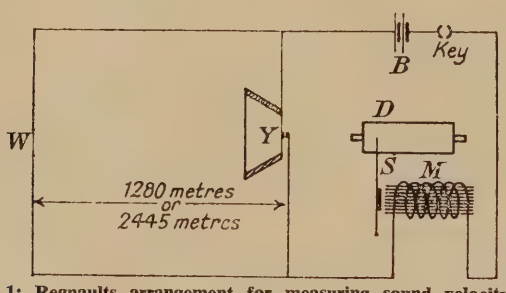


Figure 1: Regnaults arrangement for measuring sound velocity in air.

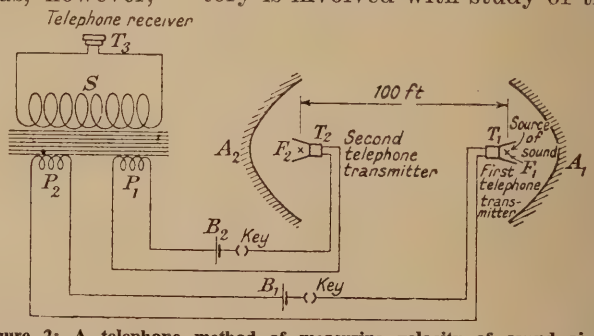


Figure 2: A telephone method of measuring velocity of sound giving greater accuracy than the set-up of figure 1.

SOME CLASSICAL EXPERIMENTS

From the 16th and 17th centuries physicists realised that wavelength frequency and velocity of sound waves were available and even then methods were available to measure all three parameters with a fair degree of accuracy.

Newton (1642-1727) was the first to determine the velocity of sound scientifically and showed that the velocity was proportional to the square root of the Elastic force/Density and obtained a value of 979 feet per second. Almost simultaneously Flamsteed and Halley (of comet fame) obtained a value of 1142 feet per second. The difference between

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these two values was not satisfactorily explained until the 19th century although a value around 1100 feet per second was accepted. Many of the early attempts were limited by reaction time of the observers and nearly all measurements from Newton's time up till the mid 1850's were concerned with reducing the "personal equation".

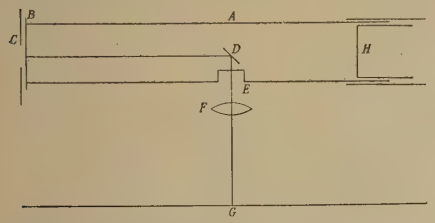


Figure 3: The Rayleigh DWC method of measuring air particle velocity and hence sound intensity (pressure).

In 1864 Regnault took an important step forward by using a chronometer drum as a time interval recorder. His set up is shown in Fig. 1. Here a gun is fired at W breaking a wire and thus registering an impulse on the drum D. Later arrival of the sound wave at Y causes a contact to be made and another impulse recorded on the drum by the stylus S. The drum is driven at a constant rotational speed so the time between the impulses can be determined. It was found that this equipment had a "personal equation" but this was greatly reduced by taking measurements over two distances. Calculations were made for propagation in both directions so that wind effects were eliminated.

At Cape Town in 1871 the colony's Astronomer Royal, Stone, used similar equipment in a different layout to reduce "operating" times and he reduced the "personal equation" to as little as .09 second and obtained a velocity of 1090.6 ft. per second (332.4 metres per second). Work in Arctic areas in still dry air produced an equation

$V = 332 + .6\ T$ metres per second

where T = temp. in °C.

The methods used above all suffered from difficulties due to the distance involved. Because worthwhile intensities were needed at the receiving end large discharges had to be used and it was thought then that the velocity adjacent to intense pressure sources was not the same as in normal transit (this has since been proved correct) and no account could be taken of wind, temperature or humidity effects during the passage of the test sound.

In 1905 Hebb produced an apparatus using telephonic equipment and it is here that the first real use was made of electrical science and it could be said that Hebb was the first to use electrical measurements (albeit in a physical manner) in acoustics. His equipment set up is shown in Figure 2.

Two parabolic mirrors A1 and A2 are arranged in line and sound energy is transmitted from F1 (a focus of A1) and received at F2. T1 and T2 are telephone transmitters in series with their respective batteries and coil primaries P1 and P2 of which the secondary feeds a telephone receiver.

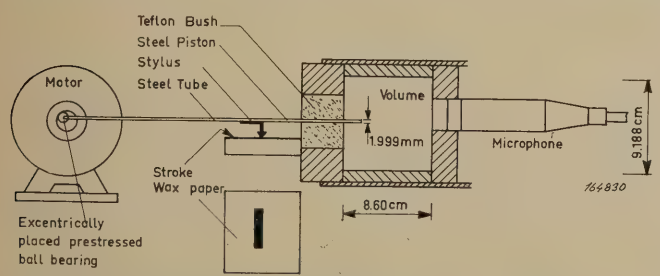
At F1 and F2 the sound source consists of a small tube closed at one end and having air blown across the open end. Care was taken to ensure purity of tone and constancy of frequency; this being checked to 1 part in 5000.

When a tone is emitted at F1 some sound is passed to T1 (with a phase relationship dependant upon distance T1F1) other waves are received at F2 and operate T2 — the phase depending upon F1A1A2F2 and the vector sum will be heard in the receiver at T3. Assuming that the intensities are equal (and the short distances involved are a reasonable assurance of this) it is possible by moving one mirror to change the relative phases so that reinforcement and cancellation can be obtained. Thus wavelength can be accurately determined — 1 part in 1000 being claimed by Hebb. The mirrors used were plaster of Paris moulded 5ft. in diameter with a focal length of 15 inches. The whole experiment was conducted in a hall 120 ft. long, 10 ft. wide and some 14 ft. high. The result obtained for sound in air, corrected to 0°C was 331.46 metres per second.

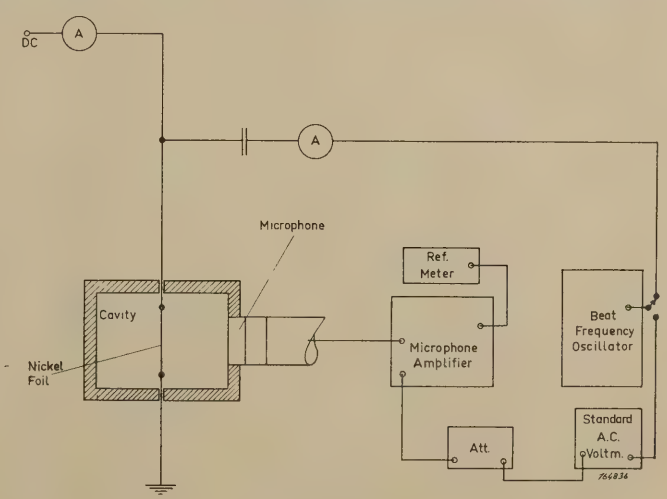
This result was in accord with the best results obtained in the late 1800's by Arago in France where 331.2 metres per second for 0°C was obtained.

THE RAYLEIGH DISC

In 1880 Lord Rayleigh described a device to the Cambridge Philosophical Society that he had used to determine air velocity. Based on the principle that a very light disc will set itself at right angles to an air-flow the deflection



Above: Figure 4. The classic Piston phone. Modern instruments use a double piston chamber (after Bruel and Kjaer).



Right: Figure 5. The Thermophone method of intensity measurement for calibration of microphones (after Bruel and Kjaer).

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can be used to measure both steady and pulsating (alternating) velocities. The Rayleigh Disc principle is shown in Figure 3 where A is a metallic tube closed at one end by a glass plate B illuminated through a small slit C. D is the disc fronted by a mirror that reflects the light beam through a window E and lens F onto a scale G. H is a moveable acoustically transparent screen of paper or similar thin material adjusted so that the tube length can be made a half-wavelength for the frequency involved.

The spot deflection can be shown to be equal to

$$4/3\ \lambda r^3\ V^2 \sin 2\phi$$

where λ = air or gas density.
V = velocity of air or gas (either steady or RMS)
r = radius of the disc
ϕ = angle from normal of disc to air flow (ϕ usually about 45°)

Later workers, in the 1920's, made measurements of air particle velocities down to .1 cm/sec with an accuracy of 2% and this corresponds to a fairly intense sound wave and intensities below 50dB or so require special measuring refinements. Nevertheless, the Rayleigh disc has been used for a number of years as a primary means of measurement of absolute sound intensity. Its result which measures velocity, is then compared with those from a pressure microphone and the air velocity value converted to pressure by using known relationships. Capacitor microphones so calibrated, are considerably more robust than a Rayleigh primary Standard.

Whilst the Rayleigh disc is, perhaps, the classical method of microphone calibration (or intensity measurement), later methods have superseded it. For instance, ideal Rayleigh calibrations can be made to an accuracy of 1dB whereas more modern methods can increase calibration, or intensity measurements, to an accuracy of .1dB.

One method, not now much in favour, but adopted some 30 or 40 years ago as a more accurate method than the Rayleigh disc (except for its most sophisticated forms) was perfected by the Bell Telephone Company in America.

When an alternating current is passed through a thin wire, suitably suspended, the wire is subject to temperature changes corresponding to the current periodicity. With wires suitably mounted, temperature waves are produced in the surroundings and the heating effect can be limited to the space adjacent to the wire. Expansion and contraction of the surrounding medium occurs which, in turn, produces pressure waves which are transmitted as sound.

To obviate some difficulties in this instrument (known as the Thermophone) a D.C. voltage is also applied to the wire. The wire is in practice a piece of nickel, platinum or gold strip or foil up to 1 cm wide and under .001 cm thick. Figure 5 shows a modern set up using the thermophone principle to calibrate a microphone. The thermophone is limited in low frequency response being more suited to measurements in the range 100 — 10,000 c/s.

Frequencies below 500 c/s can be very well dealt with by a mechanical device — the Piston phone. In this method the microphone to be calibrated is located in a cylinder the other end of which has a piston moving with sinusoidal motion driven mechanically by a motor or electromagnetic driver.

If the RMS amplitude of the piston is d then the RMS sound pressure in the chamber

$$= \frac{d\ A\ P\ \beta}{V}$$

where P is the atmospheric pressure
A the piston area
β the specific heat of the air or gas in the cylinder
and V the effective volume of the enclosure

The pistonphone method is now the one used for everyday calibration of microphones and accuracies of at least .2 dB can be achieved with little effort and time.

In all there are seven methods of microphone (or sound intensity) calibration:—

1 Rayleigh Disc
2 Thermophone
3 Pistonphone
4 Smoke particle movement
5 Disc lifting by pressure method
6 Electrostatic actuator
7 Reciprocity methods

The methods not dealt with here (numbers 4 to 7) are worthy of separate discussion and will be the subject of a later paper on microphones and microphone calibration.

The classical and historical aspects of the subject have been dealt with in fair length to emphasise that in acoustics, as apart from audio engineering, much of the theory, and even some instrumentation, goes back to the late 19th century. The advent of electronic instruments and equipment has only meant speedier and easier application of knowledge gained in the "pre-electronics" period together with greater accuracies in measurement.

In the concluding part of this paper we will deal with actual system requirements and instrumentation needed to determine what engineering and equipment is required to fill specific needs.

This section will include discussion on audio oscillators, wave form and distortion analysers, wave form and level recorders and the limits of accuracy required to fulfill specification requirements.

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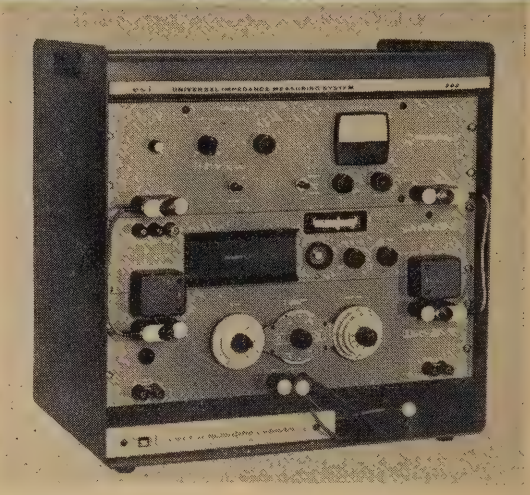

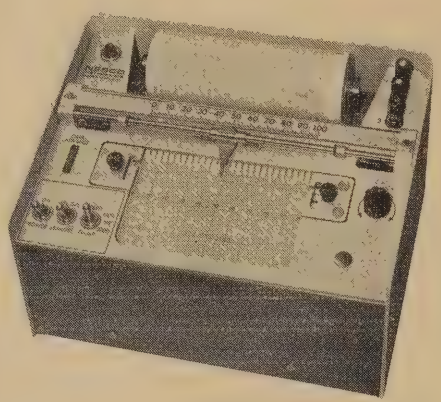

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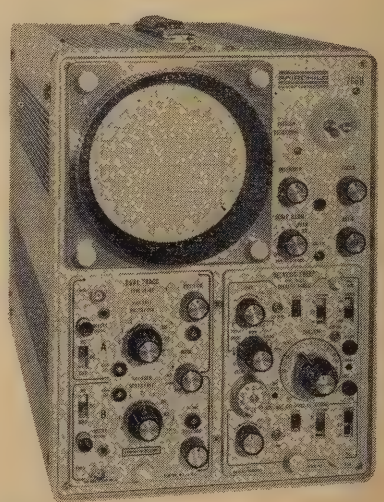

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Mobile Communications – *Part VII*

by Countryman

In a previous article I discussed a general specification for an ideal radio telephone set for mobile use. In setting down the ideas, which were largely those reached in general discussion with experienced technicians and engineers, and of course my own observations, I avoided anything in the way of figures. The reason for this was twofold. Firstly, setting up a specific figure which a set should in theory meet is a hazardous occupation, because there are so many things that may render it invalid. Secondly the question of the standards to be set is worth an article on its own. As an example of the first trap I can relate what happened to me when arranging the purchase of a new set. I asked for a very high degree of selectivity from the receiver, one which I had measured in the laboratory on valve type equipment. To measure this order of attenuation it was necessary to feed in a signal of about 1 volt, 10 KC/s off frequency. This is not to difficult to achieve with a valve set, where intermodulation due to the curvature of the RF stage characteristic is fairly low. But with a transistor stage its very much more difficult. You see most of the selectivity is achieved in the IF stages, so the first RF transistor will have to handle about 1 volt of signal, and this is very tricky! The selectivity may be achieved, but it is not possible to measure it by the usual methods.

In NZ the manufacturer is required to meet the standards layed down by the Radio Regulations, which govern such things as power output, harmonic radiation, and frequency tolerance, In addition the Post Office has a "type approval" which lays down additional specifications for such things as sensitivity, selectivity and power output. The purpose of this is to ensure that at least a minimum standard will be set to ensure that the customer gets his money's worth. There is of course nothing to prevent a manufacturer exceeding the NZPO requirements, except that to do so would involve him in development costs which he would find it difficult to recoup.

In the United States things are very different. With more than 2½ million mobile sets in use the mobile field has attracted many manufacturers, and the spur of competition has resulted in the establishment of high technical standards. It would be no exageration to say that in this field the NZ manufacturer is about 20 years behind the times. Let me give two examples. In the matter of harmonic radiation the requirement in NZ is that this must be at least 40dB lower than the fundamental. In the U.S. the present day requirement is 80dB. Frequency tolerance allowable in NZ is 0.01%, that is the carrier is required to be not more than 100 cycles per megacycle from the allocated frequency. Thus a station on 4.5 mc/s would be permitted to drift not more than ± 450 cycles from its centre frequency. In the United States the tolerance for mobiles is 0.0005% that is 5 cycles per megacycle of carrier frequency. In other words the frequency accuracy required is in the same order as that required of NZ broadcast stations. But, let me remind you, that this is not a large crystal controlled oscillator in the air-conditioned interior of a stationary transmitter, but in a small metal box subject to violet changes in temperature and supply voltage, and being shaken and bumped about in a car or truck for good measure! As you can see this implies an extremely high standard of engineering on the part of the component and set maker, and also on the part of those responsible for design and maintenance.

It would be foolish to pretend that this could not be done in NZ. If there is one thing that the NZ radio manufacturer has clearly shown over the years it is that he is capable of producing equipment of the highest standard. One factory during the war produced a line of high power transmitters which had an excellent reputation for both performance and reliability, and since then NZ built equipment has on several occasions competed with and beaten the best of overseas equipment on a world wide basis.

Why is this not being done in the mobile field? It must be because major users are prepared to accept inferior articles. By and large, Government departments are the biggest users of Mobile in NZ today, and as such must shoulder a large portion of the blame for the poor state of the art. While technical officers may wish to improve the standard of equipment in use, such sets will cost a good deal more than an average sort of set. Government Stores Board purchasing procedures are such that to purchase other than the cheapest set offered is made difficult and time consuming, so that it is often necessary to accept an inferior set in order to get something into use when it is needed. With this sort of atmosphere prevailing, the local manufacturer cannot be blamed if he is reluctant to spend thousands of pounds on development of improved equipment knowing that if he raises the price of his set he will not be able to sell it!

There are signs that a change in this attitude is taking place. In common with other Government contracts there is an increased awareness on the part of those who hold the purse strings that the most economic approach to the purchase of equipment for radiotelephone is not always to buy the cheapest. One department has recently called tenders for the development of equipment to an extremely high standard. This may just be the break through that is required to produce the leap ahead sorely needed in Mobile radiophone.

Although it is not actually stated in this article, the author is referring particulary to tolerance specifications for the M.F. (medium frequency) allocations. The frequency tolerance of .01% refers to base station equip-

Continued on page 33

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SERVICEMAN'S COLUMN

continued from page 25

A word of warning. Do not try to quite reach 9 volts because there is always some ripple reaching the chain. Use an A.C. range on a voltmeter (divided by two) to verify this. About 8 volts is far enough and if two 5000 ohm 2 watt resistors are insufficient do not go further as the high tension voltage will suffer.

What of the regular faults that are peculiar to these portables? The convertor valves IR5, or continental equivalent, DK91, stop converting with very slight reduction in emission. They must be replaced but will still work in lieu of an IT4 as R.F. amplifier if you have the luck to lose a IT4 (or DF91). One half of the output valve filament (3V3 or similar) will often o/c. These valves will work on half power with a jumper across the offending section, it is a matter of economics as the output power still available is greater than many transistor portables.

These sets have lots of tatty low (150v) voltage bypass condensers. They look horrible but usually do not detract from performance. The feed resistors to the voltage audio stage are of 2 megohm order. These may have aged and reached much higher values. They should be replaced in such cases.

The speakers sometimes need repair or replacement, remember that the output transformer should be at least 10,000 ohms primary impedance.

Old valves are prone to failure as the fine heating filaments are both brittle and susceptible to sagging.

In conclusion one might ask — is it worth it? Yes, if the set is still of presentable appearance. No, if the owner has popped all the valves. My advice to an owner is that the set was well designed and well made. It is worth spending £2 on or represents a good buy if in working condition at £5. A wonderful present for junior. After all what can you buy for less than £5 that he or she has not already got.

Mobile Communications

continued from page 31

ment, whereas the frequency tolerance for mobile equipment in this service is .005%.

In all cases, the specifications as laid down by the N.Z. authorities are in accordance with the International Radio Regulations as set down by the Geneva Convention, and to which New Zealand is a signatory. It is therefore a difficult task to compare standards as set for this country, which falls in Region 3 of the International allocations with those of the U.S.A. which complies with regulations as set down for Region 2.

—Ed.

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ENQUIRY CARD AD. 19

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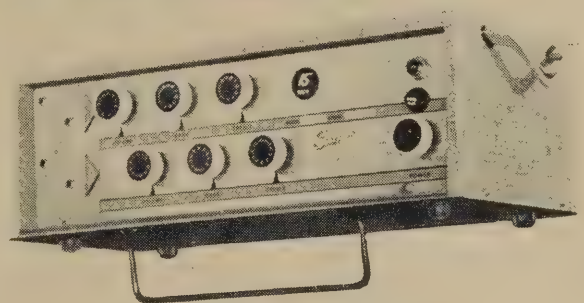

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ENQUIRY CARD AD. 20

Advance

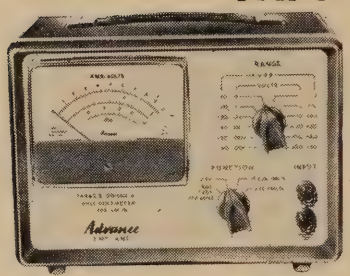
millivoltmeters & transistor tester

VM77B

A.C. Millivoltmeter

Voltage ranges 0·001, 0·003, 0·01, 0·03, 0·1, 0·3, 1, 3, 10, 30, 100, 300V F.S.D. *Frequency range* 15c/s to 4·5Mc/s. *Accuracy* ±3% F.S.D. 15c/s to 2Mc/s, ±(3% + 3% F.S.D.) 2Mc/s to 4·5Mc/s. *Accuracy* ±(3% + 3% F.S.D.) 2Mc/s to 4·5Mc/s. *Accuracy* ±2dB. *Input impedance* 10MΩ, 20pF (approximately 60pF using lead PL50 supplied. Lead PL45 is available as an accessory with 10: 1 capacity divider fitted). *Stability* ±1% for supply variations between 105 and 125V or 210 and 250V (15c/s to 2Mc/s). Less than 1·5% at 100V and 200V. *Non-sinusoidal operation* Readings close to r.m.s. values are given even when the harmonic content of the input is high. *Amplifier* Gain 60dB maximum in 10dB steps. Maximum output 1V r.m.s. Frequency response ±2dB, 12c/s to 200kc/s. Response from 200kc/s to 5Mc/s depends on load. Output impedance 1500Ω approximately. *Power requirements* 100 to 125V, 200 to 250V, 50 to 60c/s, 30W. *Dimensions* 8⅞in (23cm) wide × 6½in (17cm) high × 5½in (14cm) deep. *Weight* 7lb (3·2kg).

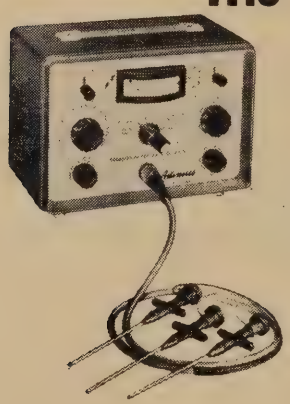
VM78



Battery-operated Transistorised A.C. Millivoltmeter

Voltage ranges 0·001, 0·003, 0·01, 0·03, 0·1, 0·3, 1, 3, 10, 30, 100, 300V. *Overload protection* Protected for inputs up to 400V peak on 0·3V and higher ranges, and for 100V r.m.s. on 0·1V and lower ranges. *Frequency range* 1c/s to 1Mc/s. *Accuracy* ±3% F.S.D. *Input impedance* 2MΩ shunted by approximately 30pF. *Temperature range* 0 to +45°C. *Noise* Less than 50μV referred to the input, when terminated in 47kΩ or less, on the 0·001V range. Residual reading less than 3% of F.S.D. on all other ranges. *Dimensions* 8⅞in (22·5cm) wide × 6½in (16·5cm) high × 5½in (14cm) deep. *Weight* 6·6lb (3kg).

TT1S



Transistor Tester

Battery operated for testing p.n.p. or n.p.n. transistors in situ.
Current gain (*Beta*) 10 to 100, 50 to 500. Accuracy with transistor out of circuit, ±5%; with transistor in circuit, dependent on base shunt circuitry. *Set current* Nominally 1 to 50mA (dependent on shunt circuit). *Balance* Shunt collector circuits of greater than 100Ω can be balanced out by the instrument. *Leakage current measurement* (grounded emitter I'co) 0 to 100μA and 0 to 1mA, with transistor out of circuit. *Diode measurements* Reverse leakage measurement as for I'co. With 10mA of forward current, meter will indicate voltage drop across diode (2V F.S.D.).

Dimensions 8⅞in (22·6cm) wide × 6½in (16·5cm) high × 5½in (14cm) deep. *Weight* 6¼lb (3·1kg).

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FROM THE COMPREHENSIVE RANGE OF Advance INSTRUMENTS AND EQUIPMENT

A 30 WATT AUDIO AMPLIFIER

Continued from page 14

$$\eta 1 = \frac{Ps}{2Ia \cdot Vak} = \frac{40}{0.223 \cdot 250} = 72\%$$

A calculation of the overall efficiency $\eta 2$ shows:

$$\eta 2 = \frac{P \text{ (measured across Raa)}}{21a\ Va + 21g_2\ Vg_2}$$

$$= \frac{36.5}{0.223 \cdot 265 + 0.045 \cdot 265}$$

$$= 51\%$$

The screen grid current rises considerably (by a factor of about 5) when the output stage is driven from zero to full output; this implies that the d.c. source for the screen grid supply should have a low internal resistance to prevent unnecessary limiting of the available output power.

CIRCUIT DESCRIPTION

In Fig. 4 we give a complete amplifier circuit that is based upon the considerations set forth in the preceding section.

The input pentode EF86 serves as voltage amplifier. It is followed by an ECC82 operating as driver and phase inverter; the even harmonic distortion at the output can be minimised by adjusting with balance control P1 the symmetry of the drive signals fed to the output tubes. By this procedure small differences in the characteristics of the two output pentodes can be compensated for.

To suppress parasitic oscillations small RF chokes are inserted in the screen grid leads of the EL503's; moreover 3.9 kΩ resistors are included in the control grid leads.

An overall feedback path (20 dB) runs from the secondary of the output transformer (5 Ω) to the cathode of the EF86; an appreciable reduction in distortion is the result.

To suppress any tendency to instability at high frequencies three correction networks have been incorporated. The 820 pF capacitance in the feedback loop and the RC combination (2.7kΩ and 5000pF) across the transformer primary serve to eliminate the influence of the stray inductances in the transformer. The RC-combination (1.5kΩ and 470pF) parallel to the anode resistance of the EF86 helps to reduce the gain at very high frequencies. A check of the frequency response by means of square wave signals is helpful for determining the required values of the various damping elements, these being strongly dependent upon individual transformer design.

TEST RESULTS

The results obtained have been plotted in Figures 5 and 6. Up to 32 watts of output power are available with less than 1% distortion; above 32 watts the harmonic distortion increases as a result of limiting effects. The distortion consists predominantly of 4th and 5th harmonics. The power which is actually **supplied** by the output stage is higher than the available output power, being Ps = 40.6 W for 1.5% distortion and 42W for 5% distortion. These figures are slightly more favourable than those obtained in the case of the experimental output stage of Fig. 1.

The frequency response is linear from 20 c/s up to about 20 kc/s; the –3 dB points are 10 c/s and 50 kc/s respectively.

All voltages specified in Fig. 4 are measured under no-signal conditions.

LISTENING POST

— **Continued from page 24**

EGYPT. 17920 is the frequency used by U.A.R. for a transmission in English to India from 1330-1430 and in Urdu from 1430-1530.

VATICAN. Vatican Radio broadcasts an English transmission to India from 1550-1610 on 15120.

SOUTH AFRICA. Radio South Africa has been heard in Wellington around 1715 broadcasting the Africa Service on 15220 and 4975.

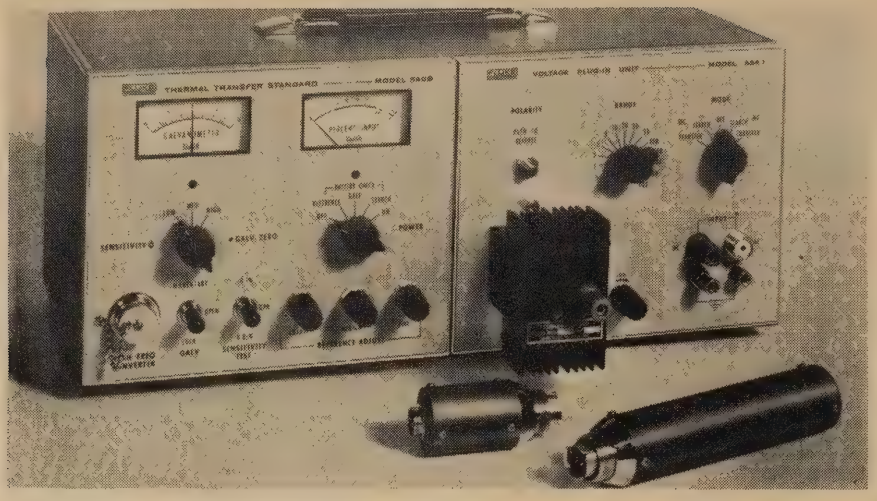
The full weekday schedule for the Africa Service is: 0300-0400 on 6150 and 7270; 1000-1710 on 15220 and 17805; 1710-1845 on 11900 and 15220; 1845-2000 on 9525 and 11900; 2000-2115 on 7270 and 9525; 1600-2115 on 4975.

GREAT BRITAIN. The English language section of the European Service of the BBC transmits according to the following schedule: 0400-0430 on 5975, 7120, 6110 and 7260; 0600-0630 on 3952.5, 5990, 6050, 6150, 7210, 7260, 9765 and 11905; 0700-0715 on 3952.5, 5990, 6050, 6150, 7210, 7260, 9765 and 11905; 1015-1030 (weekdays) on 9510 and 11945; 1300-1315 on 7155, 9510, 9760, 11780, 11945, 12095, 15180, 15235 and 17695; 1715-1830 on 3952.5, 5975, 6110, 7185, 9735 and 9770; 2100-2115 on 3952.5, 3975, 5975, 6180, 7185, 7230, 7325, 9600, 9770 and 9825; 2230-2245 on 3975, 5975, 5990, 6180 and 7260.

SWEDEN. The current English language schedule of Radio Sweden is as follows:— To Europe at 1100 and 1400 on 9620 and at 2200 on 6065; To the Far East at 1100 and 2345 on 7270 and at 1230 on 7270 and 11810; To Eastern North America at 1400 and 1445 on 15420 and at 0145 on 5990; To Western North America at 0315 on 5990; To South Asia at 9765; To the Middle East at 1615 on 11705; To Africa at 1945 on 11705.

A DX programme is broadcast from this station every Tuesday.

New Products



NEW THERMAL TRANSFER STANDARD

For ±.01% RMS ac transfer measurements without calibration curves or correction tables, Fluke offers the new all-solid-state Model 540B AC/DC Thermal Transfer Standard. Thermocouple burnout is eliminated by a unique protection circuit. In addition, a search circuit provides visual indication of the percent of rated input. DC input to the thermocouple is reversed via front panel switch to conveniently check its reversal characteristic which is guaranteed to be less than 0.01% of input. Self-contained galvo is Fluke Model 840B solid-state electronic type. A unique feature is the sensitivity test control which causes galvanometer deflection exactly equivalent to an input level change of 0.1% or 0.01%. This feature is extremely useful in checking either the internal thermocouple DC reversal characteristic or the frequency response of a device under test. One configuration of Model 540B is used for both bench and rack mounting.

Accessories include A40 Current Shunts for AC/DC current transfer measurements to 10 amps. and A55 Thermal Converters for extension of frequency range to 50 MC.

Voltage range is 0.25 to 1,000 V in 14 ranges and galvanometer resolution is 0.0012% / scale division at rated input. Dimensions of the cabinet model are seven inches high by 17 inches wide by seven and three-quarter inches deep. The rack model is two inches wider.

ENQUIRY 261

PROXIMITY SWITCHES

American - manufactured proximity switches marketed in N.Z. by P. H. Rothschild function as limit switches, positioning controls detection devices or sensing elements for all types of counter.

Each proximity switch consists of a central amplifier sensing head and connecting cable. The sensing head detects all stationary and moving metals, including non-magnetic, without contact and sends an electrical impulse to the control amplifier which automatically actuates a relay to control electro-mechanical or electronic devices.

Numerous models are produced to fill the needs of industry where they have countless applications.

ENQUIRY 253

* * *

TELEPHONE QS DIVERSION UNIT

A telephone diversion unit, called Divertafon, to be marketed throughout the world by an Australian electronics company, can be used without adjustment on six different exchange systems and fitted to any telephone system in the exception of a few in the US.

It has undergone exhaustive tests by the Australian Postmaster General, who controls all telephone systems in Australia.

The instrument can be used with Pre-2000, 2000 type, 2000 type line finders, Siemens motor driven exchange, L. M. Ericsson crossbar type and the French Pentaconta system, without any adjustment being necessary.

Full details of operation have not yet been revealed, but it is known that a solid state detector is used to detect incoming calls. This operates a relay to start the outgoing call system. At this time the outgoing line is examined for reverse line pairs, premature reversal and dial tone.

ENQUIRY 175

ENQUIRY CARD AD. 21

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ENQUIRY CARD AD. 22

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ENQUIRY CARD AD. 23

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DIGITAL VOLTMETER AND OSCILLOSCOPE

Two new instruments have been released this year by Advance Electronics — the DVM1, a digital voltmeter with a specification that includes facilities for dc and ac measurement, and the OS15 — an oscilloscope aimed at the educational field and for general purpose use in industrial applications.

The DVM1 provides facilities for dc measurement from 1mV to 2000V dc as well as ac measurement from 1mV to 1000V. This is an instrument with a fully solid state circuit with mechanical operation limited to the front panel controls only, giving a high reliability and fast conversion time.

The 0S15 oscilloscope is designed for simple operation in the range DC-3Mc/s and with fully calibrated controls. Because it is most suited to educational needs, Advance are offering it at a special price to educational establishments. Servicing of the OS15 is also simplified because only one type of valve is used throughout and the majority of the components are mounted on a single printed circuit board.

ENQUIRY 254

* * *

TELEMETRY AND REMOTE CONTROL SYSTEM

A telemetry and remote control system worth more than £20,000 has been ordered in Britain by the Wrexham and East Denbighshire Water Company for the first stage of a programme for centralised control and supervision of its area. The equipment provided will cover a number of out-stations, including pumping stations and reservoirs. The remote control, supervisory and telemetry equipment to be installed will enable out-stations to be monitored and controlled from a control centre being established at the company's Wrexham headquarters. There is also provision for local control at remote points. Information and control signals will be transmitted between the control centre and the out-stations over G.P.O. rented lines.

ENQUIRY 265

* * *

LOW-COST 2-MC CPS PUSH SOLID-STATE COUNTER

The 2-mc model 6020 preset counter from the Berkeley Division of Beckman Instruments Inc. performs accurate measurements of physical quantities directly in engineering units such as rpm, pressure, flow, etc. The desired conversion factor can be selected through the combined use of a 5-decade preset selector and multiplier from 10 microseconds to 100 seconds.

The preset selector provides 5 decades for selecting any number from 1 to 100,000 which in turn can be multiplied by 1, 10 or 100 with the multiplier selector. The combined use of preset selector and multiplier provides a wide choice of gate times, timing and count multiples and the advantage of a preset output for external control indication or simulation application.

Low-frequency measurements can be made by timing up to 10^7 periods with 10 microsecond resolution. With the two inputs provided, two frequencies up to 2-mc can be measured simultanously for ratio determination. By selecting multiples of the lower frequency up to 10^7, ratio measurements are made with a high degree of accuracy. Random events of up to 10^7 counts can be totalled.

ENQUIRY 252

* * *

PLUG-IN SWEEP GENERATORS

The N.Z. agent for Teltronics has announced a complete line of small light sweep generators that attach directly to most oscilloscope front panels. These Micro-Sweeper units will sweep IF and FM stages for alignment and wideband amplifiers. They are useful in the field as test equipment for both sweep work and as fixed RF generators. Cables and batteries are unnecessary; the unit is operable immediately it is plugged into an oscilloscope.

Three models are available, covering .15 and 115 mc; three overlapping bands each. Each unit has an independent sweep width control and independent centre frequency control. Fully transistorised the Micro-Sweepers have printed circuit boards and removable back covers.

ENQUIRY 257

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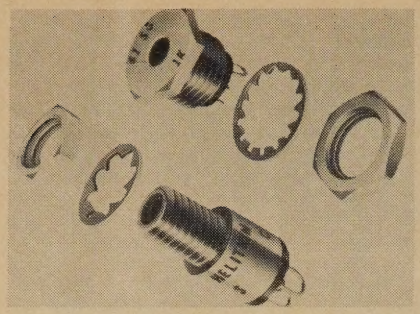


NEW TRIMMING POT MOUNTING STYLES

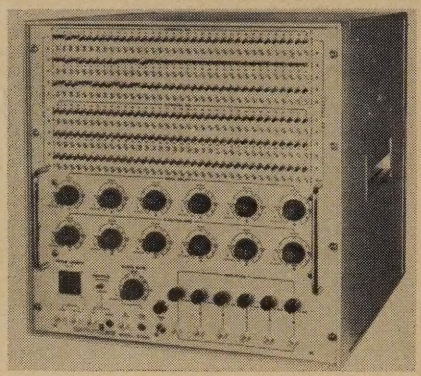
Models 61SB and 61SG are panel mounting versions of the ¼ inch diameter Helitrim Model 61 trimming potentiometer. Cermet resistance element offers essentially infinite resolution with a ½ watt power rating at 85°C, derating to 0 at 150°C. Eighteen standard resistances from 10 ohms to 1 megohm are available.

ENQUIRY 258

* * *

DATA GENERATOR

Model 206M data generator provides six channels of serially programmed pulse outputs in NRZ or RZ (variable width) format with 72 bits per channel and independent delay, width, and amplitude for each channel. Auxiliary sync pulses, clock pulses, and command functions available permit test and evaluation of a wide range of high speed tape and memory devices, and other multi-channel pulse equipment. Internal clock rate is continuously variable from 2 cps to 2 Mc. Provision is made to slave the unit to an external signal source, and a single clock may be generated for each operation of a front panel push-button.



Six channels of serial data are available with one independently variable output provided for each. 1/0 content of each bit in each channel, up to 72 bits, may be independently toggle switch programmed. Serial word length is selectable from 1 to 100 serial bits. Serial words may be repeated continuously, or recycled manually by panel push-button, or by initiation of external command signals. Data format is independently selectable for each channel as NRZ or Variable Width. Data delay is independently controllable for each channel as zero, or continuously variable from less than 50 nanosec to 5 millisec.

Sync Output is positive 6v pulse, approximately 50 nanosec wide, with 100Ω source impedance. Clock Sync occurs at the data rate. Bit No. 1 Sync occurs coincident with the first bit in each word.

Dimensions: 19"W x 19-1/4"H x 22"D relay rack mounted. Weight: approximately 40 lb. Power required: 105v to 125v ac, 50/60 cycles, approximately 100w. New Zealand agents offer service calibration facilities.

ENQUIRY 259

* * *

NEW TELEQUIPMENT OSCILLOSCOPE

The AWA Telequipment oscilloscope, type D53 accommodates all the 43 range of amplifiers, together with two new amplifiers which will offer signal delay on both beams; these are to be known as CD and HD amplifiers (these latter amplifiers cannot be used in the 43 series). The type D53 is a double-beam oscilloscope with interchangeable amplifiers and time bases.

The CD and HD amplifiers will be the same price as the C and H amplifiers respectively. Production of this oscilloscope is scheduled for March 1966. Initial availability from AWA will be against firm orders, and subject to an import licence being granted.

ENQUIRY 251

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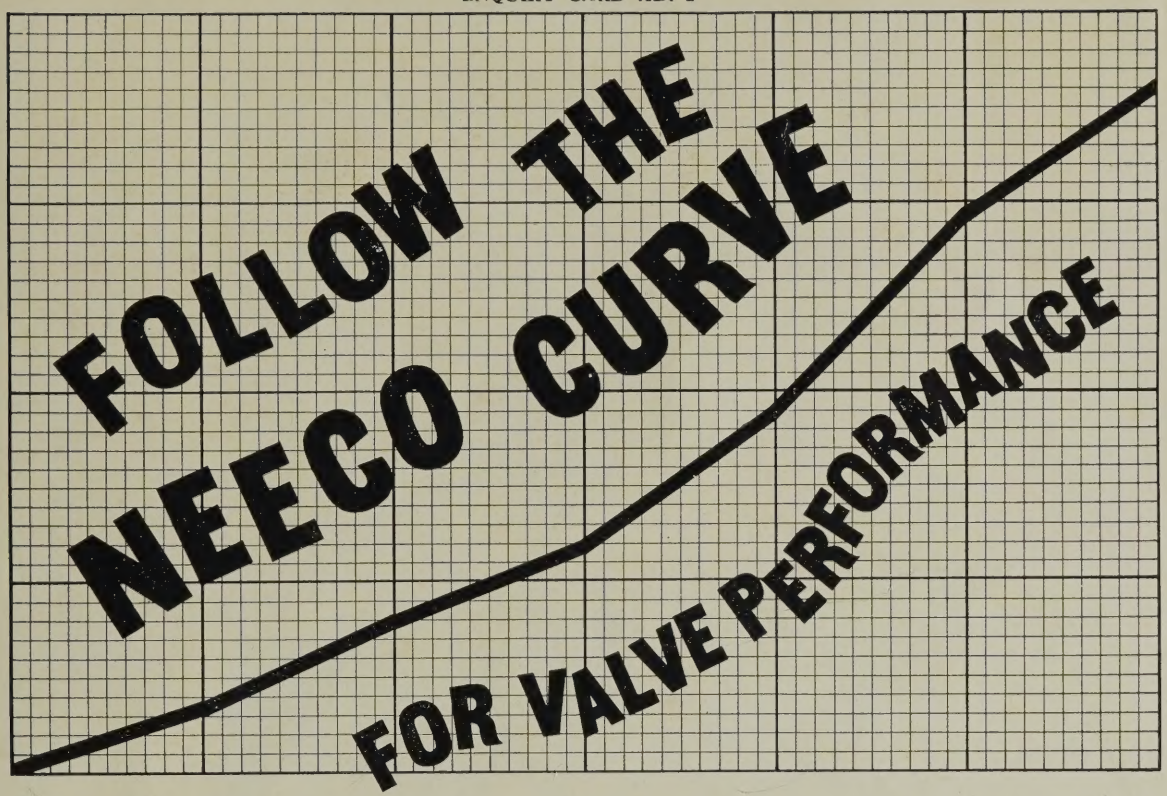

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